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ATTENTION, MEMORY, THOUGHT AND REASONING NUMBER

EDITED BY E. S. ROBINSON

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THE PSYCHOLOGICAL BULLETIN

ATTENTION

BY KARL M. DALLENBACH

Cornell University

More studies and researches have been reported during the past three years upon the general topic of attention than in any similar period of the history of the subject. One book and thirty-three articles have appeared during this period—which is more than were published during the six-year period covered in the last general summary,¹ and almost as many as were published during the decade previous to that.²

As in the last summary of the work on attention, the studies are classified for the purposes of the present review into the following four groups: (1) those that are concerned with the definition and with the ultimate nature of the phenomenon; (2) those that deal with some special aspect of the subject, such as range, fluctuation, etc.; (3) those that treat of attention in relation to some other phenomena; and (4) those that are technological, that were undertaken because of their practical significance.

1. DEFINITION AND ULTIMATE NATURE

(a) *General.* Henning (15), in his book on attention (which was reprinted from the sixth section of Abderhalden's *Handbuch der biologischen Arbeitsmethoden*), treats of the subject very broadly. He not only considers the topics that are traditionally discussed under attention—such as range, kinds, levels, fluctuation, distraction, distribution, accommodation, measurement, adaptation, and fatigue—but

¹ Dallenbach, K. M., this BULLETIN, 1926, 23, 1-18.

² Cf. the summaries of attention by W. B. Pillsbury, this BULLETIN, 1910-1920.

he also devotes separate chapters to the rôle of attention in abstraction and analysis, to the relation of attention and memory and of attention and feeling, to the physiological accompaniments of attention, to the psychotechnology of attention, to insistence and vividness, apprehension and clearness, to the Wundtian concepts of clearness, and to a brief statement of the principal attentional theories. He closes his book with a presentation of a new theory—a psychophysical theory of sensitization (*Sensibilisierung*). He postulates the sensitization of the end-organs (through centrifugal paths), of the conducting neural pathways (through thalamic excitation), and of the cerebral cortex. His theory, in spite of attempts at a biological and physicochemical correlation, is nominal; it neither explains nor describes.

Henning's exposition of the different topics listed above is very uneven. He gives, in comparison with his other chapters, an inordinate amount of space to the chapter on Wundt's concepts of clearness. He also slights some topics. For example: he devotes but two pages to the chapter on the measurement of attention—a problem on which there is a voluminous literature and which Külpe said was "one of the most important . . . that awaited solution"; but two pages to the chapter on the physiological accompaniments of attention, in which many studies are ignored; but one page to the chapter on attention and interest; and merely half a page to the chapter on the psychotechnology of attention. It would have been better to omit these chapters than to treat them so inadequately. With these notable exceptions, Henning gives us an excellent résumé of the experimental work that has been done in Europe on all phases of the problem. He does not appear, however, to be conversant with the experimental work that has been done on the problem in this country. The reader who goes to this book must bear in mind that there is an American literature which Henning has barely touched.

Johnson (17) differentiates two uses of the term "attention" in contemporary psychology: one to designate "the degree of consciousness or the clearness of content"; and the other to designate "the degree of the sensorimotor adjustment of the organism with respect to a particular stimulus" (601). The first he instances as the typical non-behavioristic definition, the second as the definition of the behaviorists. Some authors "confuse the two concepts, others regard them as distinct and mutually supplementary" (601). Johnson's thesis is that they are mutually independent. After an exposition of the two different points of view, Johnson examines the results of a

"crucial experiment" by Cassel and Dallenbach³ in which auditory sensory reaction-times and clearness values of the conscious content are reported separately. Because the correlation between the reaction-times and clearness values is low ($r = -0.25$, $p.e. = 0.025$ —which he figures is "but 3% greater than the precision based on a mere guess"), Johnson concludes "that the degree of clearness and the degree of sensorimotor adjustment are practically unrelated" (606); that there is "no reason why a description of attentive behavior, made in strictly objective terms, need be accompanied by a discussion of clearness of content, to complete the exposition of facts relevant to the former topic." (606)

Dallenbach (3) in a reply, which will be considered in greater detail in the section devoted to measurement, points out that Johnson's statement of the non-behaviorists' views of attention is inaccurate, that J. has confused cognitive and attributive clearness, and that J. is in error when making "degree of consciousness" synonymous with "clearness of content." The phrase "degree of consciousness" from the point of view of the psychologists who regard attention as sensory clearness, is as nonsensical as the phrase "degree of matter" would be in physics.

Bertrand (1), with the assistance of a teacher in a nursery school, attempts to trace the psychogenesis of attention. He has 36 Ss, 18 boys and 18 girls, varying in age from two years two months to six years. His method is as follows: An S is allowed to choose a game from a number placed upon a table before him and to do what he wishes with it for as long a time as he pleases. The selection of the game is regarded as an activity of spontaneous attention, and the time that he plays with it as the expression of voluntary attention. Every S, except those who were absent, was examined 18 times. Bertrand finds that the length of time that the children attend to a game, *i.e.*, continue to play with it, varied greatly for the different days, and that there is an age and sex difference—the means of his times increase with age, and are larger for the girls between the ages of 4-5 and 5-6 years than for the boys. He also finds that the means vary on different days of the week, and on the days following holidays.

Galdo and Papa (12) find that pronounced changes occur in the circulation of the brain during visual attention. As they have

³ Cassel, E. E., and Dallenbach, K. M., An Objective Measure of Clearness, *Amer. J. Psychol.*, 1918, 29, 205-207.

observed no characteristic or constant changes in the cerebral circulation during muscular effort, they are led to explain this difference as being due to the greater amount of work involved in mental than in physical labor. They point to these circulatory changes as evidence that the brain cannot fulfill its psychical function without physiological modifications.

Rubin (27) denies the existence of attention. He holds that attention is a complex of the perceptual world of naïve realism, and that it is the source of nothing but illusory problems. He thinks that it is an unnecessary and mischievous term, and that the sooner psychology is rid of it the better.

MacKenzie (19) gives us a philosophical discussion of the relation of sensation and attention.

(b) *Kinds*. Talhouët (32) writing at the level at which attention was considered a generation ago, discusses the activity of attention. He points out that attention is necessary for consciousness, but that it cannot last for a long time because change is a condition of mental life. Hence we are involved in the peculiar paradox—attention is necessary for consciousness and that it leads to unconsciousness—which we cannot escape unless we posit two kinds of attention. He accepts Ribot's differentiation—the spontaneous and the artificial. The first kind is absorbing, and adheres to the object; it leads to unconsciousness of self and ultimately to unconsciousness of the object. The second is cognitive, adhering to the individual; it confers new values upon mental life. Talhouët discusses and explains these two types and brings them into relation one with the other.

(c) *Clearness*. Wever (34), in an experimental and polemical study, attacks the concept of "attributive clearness." He exposes equivocal figure-ground fields tachistoscopically. In one series of experiments his *O*s are instructed to report upon the clearness of the left-hand fields. In a second series, fixation, attentional disposition, and attitude are varied according to a definite plan, and the *O*s are instructed (1) to report the type of the figure-ground experience, and (2) to give, on a 9-point scale, an absolute judgment of the clearness of each of the two fields. Wever finds, and the results of the two series of experiments are in agreement, that "in the perception of figure and ground attention plays a prominent rôle" (74). "An intimate relationship has been demonstrated [by the results of his experiments] between figure-ground differentiation and the clearness-degrees of the visual areas" (65). His examination of his *O*s'

reports on clearness "failed to reveal the sensory-cognitive distinction." Clearness is undifferentiated, "is no more what has been called 'sensory' than it is what has been termed 'cognitive'" (66). He discovers, furthermore, that this undifferentiated clearness is not limited by the dual-level hypothesis, "for it may occur in consciousness not merely in two, but in three or four or many levels, according to the nature of the experience" (74). He concludes from these findings that there is but one kind of clearness, and that "whatever distinction Dallenbach found experimentally [between attributive and cognitive clearness] may have been a function of his setting" (74). It does not seem to occur to Wever that his failure to find a distinction might also have been due to his setting.

Dallenbach (7), in a reply to Wever's criticisms and conclusions, points out that four kinds of clearness (attributive, cognitive, physiological and physical) are inextricably involved in Wever's experiments, and that it is small wonder therefore that Wever obtained nothing but an undifferentiated clearness.

Cooper (2), in an experiment upon the range of attention, corroborates Dallenbach's findings regarding attributive and cognitive clearness. He is able not only to differentiate between them, but also to say that they vary both concomitantly and independently.

2. SPECIAL ASPECTS

(a) *Range.* More than a fourth of the studies of attention that have appeared since the last summary was written bear on the problem of range; and most of them come from the Pennsylvania and Cornell laboratories.

In response to the criticism that, in his study of the range of attention, cognition, and apprehension (reviewed in the last summary), the limens were not computed in accordance with the phi-gamma hypothesis, Oberly (22) now presents his data in full. He gives in tabular form the relative frequencies of the correct judgments for every *O*, for every category (attention, cognition, and apprehension), and for every degree of assurance; he does not, however, give the new limens. The reader, if he is sufficiently interested in knowing whether the inclusion of the lower degree of assurance would greatly affect the limens, may calculate them for himself. After displaying his data, Oberly says, "We believe, however, that we were not only justified in excluding the lower degrees of assurance from our calculations, but still believe that it was the

desirable thing to do." All of which may be very well and good, but until Oberly shows the basis of his belief, until he presents some experimental evidence for the grouping of positive "do not know" answers with the "guesses," and for the omission of the lower degrees of assurance, he is not justified in arbitrarily altering an accepted psychophysical procedure.

Oberly does not consider Dallenbach's criticisms of his "transformations." He simply ignores them, and reiterates his former statements. He says in his conclusions: "Further treatment of results indicate that attention, cognition and apprehension, as defined, are proper systematic categories for psychological experimentation." Just what "indicates" these things Oberly does not say. Indeed, none of the conclusions of the study follow from his exposition.

If "range" is a question that may properly be asked of attention—Fernberger and Dallenbach have argued that it may not⁴—it must be put in terms and under conditions that escape the cognitive complications of the traditional experiments. Gill and Dallenbach (8) attempt in a preliminary study to meet these conditions. They expose cards, with from 3 to 15 geometrical forms, tachistoscopically for 60 σ , and require the Os to report merely whether the impressions aroused are at one, two, or more levels of clearness. Every stimulus-number is exposed 100 times. Limens are computed by the method of constant stimuli from the data thus collected. The results show that the range of attention greatly exceeds the limits traditionally set for it, varying for the different Os from 17 to 42 stimulus-objects. An analysis of the data reveals that size and form are objectively effective in determining range, and that position and pattern are not; furthermore, that grouping is dependent more upon subjective disposition of the Os than upon the objective arrangement.

Fernberger (10) criticizes this study by Gill and Dallenbach upon the ground that the authors have no assurance that their Os "saw all of the elements on a given card," Fernberger's premise being that "when one attempts a quantitative determination . . . one must have a check that all of the elements on a given card were in consciousness."

Dallenbach (5) admits in his reply to Fernberger that Gill and he had no assurance that their Os saw all the elements on a given

⁴ Fernberger, S. W., A Preliminary Study of the Range of Visual Apprehension, *Amer. J. Psychol.*, 1921, 32, 133.

Dallenbach, K. M., Attributive vs. Cognitive Clearness, *J. Exper. Psychol.*, 1920, 3, 229.

card, but points out that the number actually seen is of no importance, that the only matter of moment is that all the elements had the same opportunity of being seen. Dallenbach further explains the problem and shows that its solution rests upon the determination of the number of impressions that correlated 50 per cent of the time with one level of clearness, for only in that way can the cognitive complications of the usual tachistoscopic experiment be eliminated.

Dallenbach (6) follows his reply with a tachistoscopic study in which the *O*s are instructed to report, in one series of experiments, the distribution of the attentivity (attributive clearness or vividness) of their impressions during the exposure; in a second series, the number of stimuli exposed; in a third series, the number and the names of letters exposed; in a fourth series, the number and shape of geometrical forms exposed; and in a fifth series, the number, color, and shape of the forms exposed. The constant, as computed by the method of constant stimuli, differs in every series of experiments, varying for every *O* inversely with the degree of cognition. From the fact that the constant varied so greatly with the degree of cognition, and that none could be obtained for two of the three *O*s in the first series of experiments—those in which merely the attentive distribution was reported—Dallenbach comes to the conclusion that the question of range is not a proper one to ask regarding attention. The attentive consciousness is an integrated whole; and, as such, the range of attention is unity.

Cooper (2) and Hart (14), accepting Oberly's "transformations" and adopting his procedure, determined respectively the effect of brightness and of color (hue) upon the ranges of attention, cognition, and apprehension. Cooper's stimulus-cards are white. He has three series. The stimulus-objects—dots 6.5 mm. in diam.—of one series are black, of a second series, dark gray, and of the third series, light gray. The number of dots on the different cards ranges from 2 to 12. The cards are exposed tachistoscopically for 75 σ . Hart's stimulus-cards are gray and he has four series. His stimulus-objects—also dots 6.5 mm. in diam.—being blue, green, yellow, or red. The number of dots on the different cards ranges likewise from 2 to 12. The cards are exposed tachistoscopically for 40 σ .

Both Cooper and Hart require their *O*s to report—using Oberly's 5-point scale—the degree of assurance of their judgments, and they both follow Oberly in omitting from their computations of the different limens the data given under degrees of assurance 1 and 2. Besides computing limens from the data given with the three highest

degrees of assurance ($5 + 4 + 3$), they also, in accordance with a suggestion expressed by Oberly in his 1926 study, compute limens for the two highest degrees of assurance ($5 + 4$), and for the highest degree of assurance alone (5). The general results of both of these studies confirm Oberly's original findings: the limens of "attention," *i.e.*, the "immediately perceived at one level of clearness," are the smallest; of "cognition"—"the grouped"—are intermediate in size; and of "apprehension"—"the counted"—are the largest. The specific results of Cooper's experiments are that the "stimulus-intensities (*i.e.*, the brightnesses) did not seem to have any constant effect for any of the *Os*." The specific results of Hart's experiments are that color (hue) does have a constant effect. "The limens for red are constantly largest for each of the three systematic categories and for the different degrees of subjective assurance. The limens for green are similarly smallest, with those for yellow and blue intermediate." Differences in the brightness and saturation of the stimulus-colors does not explain these results, but there is some indication that the difference in the times of *Anklingen* might explain them.

Oberly (23), adhering to his position that the conscious pattern immediately perceived and at one level of clearness is to be transformed into the systematic category of attention, compares the range of this conscious pattern with that of memory. He prepares 130 series of digits, 10 series for every stimulus-value from 2-14. The series is read at the rate of one digit per sec., and the procedure is repeated until 50 reports have been obtained from every *O* for every value of stimulus. He uses two modes of presentation. In one the stimulus-values of the various lengths are presented in haphazard order so that the *Os* do not know what length to expect; in the other he presents the series in regular order, beginning with the shortest and progressing to the longest. Limens computed by the method of constant stimuli, of the "ungrouped span" (defined as the attention span) and of the "grouped span" (defined as the memory span) are compared. Those of the attention span are smaller for all the *Os*. The modes of presentation do not produce any significant difference in the results, but whatever advantage there is lies with the haphazard mode. Oberly also finds, in confirmation of Gill and Dallenbach, that grouping in the memory span is dependent more upon the subjective dispositions of the *Os* than upon the objective arrangement of the stimuli.

All of the experimenters in this series of studies are agreed as to the facts. The extent or range of report in tachistoscopic experi-

ments varies inversely with the detail of report required. They differ, however, in their interpretation of the data. Fernberger and his students regard the results as a matter of conscious pattern and identify attention with the most restricted and highest degree of cognition. Dallenbach and his students, while recognizing the differences of pattern pointed out, regard the results as due to differences in degree of cognition—a systematic category which they feel should not be confused with attention. All these experimenters seem to be coming to the agreement that the question of range is not a proper one to ask regarding attention.

Simonis (29) in a study of the mental disorders of a twelve-year-old boy, reports that the *S*'s range of attention (*Beachtens*), particularly in regard to the perception of form, is much below normal. Not only are a small number of elements correctly apprehended, but upon the repetition of the experiments, the *S* is unable to retain what he had grasped and to associate it with the new.

(b) *Conditions*. Gill and Dallenbach (8) find that size and form affect the range of attention, and that position and pattern do not. Cooper (2) finds that brightness is not a condition. His results are corroborated by Hart (14) who finds, in addition, that color (hue) is a condition—the effectiveness of red is the greatest of the four colors (R, Y, G, B) used, and of green the least. When he carries his analysis of the conditions further, he finds that neither the brightness nor the saturation of his colors explains their effectiveness, but he did obtain some evidence for the belief that the times of *Anklingen* of the different colors could be correlated with their effectiveness.

Nixon (21), in a technological study of advertising, finds that pictures of people have greater attention-value than pictures of objects; and that colored advertisements, contrary to the expected result, are less attention-compelling (except where color acts as a novel stimulus) than advertisements in black and white.

(c) *Fluctuation*. After discussing the various kinds and forms of attention and giving a hasty review of the principal problems, Rittershaus (25) turns to a study of the fluctuations of attention. He uses the cancellation test and assumes that variations in performance are produced by fluctuations of attention. The speed and accuracy—i.e., the time and error scores—with which the *Ss* cancel every line of the test are plotted, and the shape or profile of the time-curve is correlated with various effective factors. He describes first the normal curves of which he distinguishes two types: one with a set for speed in which the cancellation times are short and the

errors are many; and the other with a set for accuracy in which the times are long and the errors few in number. He explains both types in terms of attention. He then turns to a discussion of the various factors which may affect the normal course of the curves. Fatigue is the first factor considered. He differentiates two kinds: a perceptive fatigue, *i.e.*, the fatigue of sensorial attention; and an apperceptive fatigue, *i.e.*, the fatigue of intellectual attention. In perceptive fatigue the curve of the cancellation times rises and the number of errors increases; in apperceptive fatigue the curve falls and the number of errors increases. When both kinds of fatigue are simultaneously effective the curve remains unchanged and the errors increase. The results are not always so clean-cut; variations in the curves are produced by many causes and it is impossible to say from the form of a particular curve what factors have been operative.

Rittershaus turns, for assistance in the analysis of the various forms of curves, to the examination of clinical cases—to cases in which the various factors that might be operative in normal cases are exaggerated. He examines cases of arteriosclerosis, post encephalitis, senile dementia, progressive paralysis, manic-depressive insanity, melancholia, schizophrenia, dementia paranoïa, epilepsy, alcoholism, feeble-mindedness, and hysteria. He finds that it is impossible to diagnose from his curves specific mental diseases, but that certain symptoms which are common to those diseases could be differentiated. The greatest value of his tests lies not in the practical significance of his results but in the extension of our knowledge of the symptoms of the different mental diseases.

Guilford (13) gives a comprehensive chronological review of the experimental literature on the problem of the fluctuation of attention, and then proceeds to the report of his own experiments. He works in the field of vision. He uses stimulus-values—six for one *O*, four for another, and three each for two others—that were carefully chosen with respect to the limens. He finds that the fluctuations of the various stimuli depend upon their relation to the limen. Superliminal intensities are visible a longer time than liminal, and liminal a longer time than subliminal. Because visibility as a function of the stimulus limen fits the phi-gamma function very closely, and because the stimulus-value that gives 50 per cent visibility is near the liminal value, Guilford concludes that the phenomenon—the fluctuation of attention—“is nothing more than a matter of the limen.” He then examines the physiological conditions, both peripheral and central, involved in the fluctuations. From photographic

records of the eye-movements taken during the experiments he finds that local retinal adaptation and, often, winks and refixations are factors which bring about the disappearance of the stimulus, and that eye-tremors and, occasionally, winks and refixations are factors which bring about the reappearance. In experiments in which the stimulus light is noiselessly and instantaneously shifted, after its disappearance had been reported by the *O*, to the corresponding area of the other eye (or to a new area of the same eye involving the same hemisphere of the brain, or to a new area of the same eye involving the opposite hemisphere, or to a non-corresponding area of the other eye involving the same hemisphere, or to a non-corresponding area of the other eye involving the opposite hemisphere), he finds that the stimulus produces a central fatigue or inhibition, *i.e.*, a reduced readiness to respond to the same stimulus, which is relatively local, being limited to a small part of the optical sector. Guilford's general conclusion is: "Neither from psychophysical evidence nor on the basis of phenomenology can this phenomenon be called a fluctuation of attention."

(*d*) *Levels*. In a tachistoscopic study in which the *O*s are required to report merely upon the vividness of their impressions during the exposure period, Gill and Dallenbach (8) find that the *O*s always report the dual-level type of consciousness—and do so in spite of the fact that a multi-level type was tacitly assumed and even suggested in the instructions. Wever (34), in his perceptual study of attention and clearness obtains contradictory results. He finds that while "some perceptions occur with but two levels of clearness as clearness is here defined, . . . other perceptions occur with three, four, or even more levels of clearness."

Dallenbach (7), in a reply to this study, points out that Wever is not dealing with attensity, *i.e.*, attributive clearness; that Wever's "undifferentiated clearness" is a composite; and that as such his results are irrelevant to the problem. Dallenbach also calls attention to the fact that all the investigators who thought they had demonstrated the multi-level type of consciousness had worked in the field of vision with an unrestricted field where physical and physiological clearness, as well as cognitive and attributive, had an opportunity of being affective.

(*e*) *Measurement*. Johnson (16) criticized the conclusion drawn by Cassel and Dallenbach, that "attributive clearness may be measured by the average duration of the simple sensory reaction."⁵ These

⁵ E. E. Cassel and Dallenbach, K. M., An Objective Measure of Attributive Clearness, *Amer. J. Psychol.*, 1918, 29, 207.

authors averaged the reaction-times for every level of clearness and computed the correlation between these averages and the different clearness-levels. Johnson points out that such a procedure disregards the variations of time corresponding to every degree of clearness, and contrariwise, the variations of clearness corresponding to every value of time. He calculates from their data the correlation between the gross measures of time and clearness and, because it is low (-0.25), he concludes that "the results of their study did not support their reasoning."

Dallenbach (3) replies that the criticisms are irrelevant, that his and Cassel's conclusions referred to the average reaction-times, and that averaging is the very essence of the method.

Johnson (17), in a rejoinder, reiterates his former criticisms against using averages and adds that Cassel and Dallenbach's procedure is ambiguous, since he cannot understand "the meaning of the expression 'average duration' or 'average reaction-time'" (608). He thinks that there are two meanings in which the expression may be taken. It may refer (1) in a restricted sense "to the means of times which were associated with specific class-values of clearness," or (2) in an unrestricted sense "to the average of times taken without regard to numerical values of clearness associated with them" (608). Because he is unable to decide which was meant, he examines both. He proves mathematically that the second or unrestricted sense is untenable. Though he admits the truth of the conclusion if the expression be taken in the first, *i.e.*, restricted sense, he nevertheless raises three objections to it: (1) it is without practical significance; (2) it is misleading, since the restricted sense is not denoted; (3) it is irrelevant to several passages in the article.

Dallenbach (4) shows, in a review of the literature, that the attempts to measure attention by means of the reaction method had resulted in a flat failure. He explains that it would be futile for Cassel and Dallenbach, as anyone conversant with the literature on the problem knows, to compute their results in accordance with Johnson's suggestion. Cassel and Dallenbach had the choice of working up the data from a new angle or of discarding them. They chose the former course. They "thought by averaging the reaction-times that were paired with the various degrees of clearness, to eliminate the effect of other conditions (unknown and uncontrolled) and thus to discover the relations that existed between clearness and reaction" (152). Dallenbach points out, furthermore, that the restricted mean-

ing of the expression "average reaction-time" was denoted, and he answers in detail Johnson's specific objections.

(f) *Prior entry.* Stone (31) points out that the auditory-visual and the tactual-visual complication experiments, which have been used to demonstrate the law of prior entry, are subject—because of continuously moving visual stimuli—to two sources of error, viz.: eye-movements and a temporal preparation, and that both these sources of error are avoided in her experiments with auditory-tactual complication. Her apparatus is so arranged that the tactual stimulus occurs 60 and 30 σ before the auditory stimulus, simultaneously with it, or 30 and 60 σ after it. She has two series of experiments: one with attention predisposed to sound; the other with attention predisposed to touch. Fifty presentations are given to each *O* with every stimulus-interval and under each predisposition. The *O*s are instructed to report which of the two stimuli, if either, comes to consciousness first. The data are treated by the method of constant stimuli, and limens of simultaneity are obtained for each stimulus under each predisposition and for every *O*. The results show that "the latent time of the sensation for which *O* is attentively predisposed appears to be less than the latent time for which the *O* is not predisposed," the difference being "of the order of 50 σ " (287).

(g) *Distraction and distribution.* Sengupta and Sinha (28), in an experiment in which practice effect was eliminated, find that their *S*s do better in a cancellation test when they worked together in groups than when they worked in isolation. They explain this result as being due to the facilitating effect of the distraction of the group upon the attention of the individual. "The strain necessary to avoid the disturbance of the group leads to increase in the degree of attention given to the task prescribed. This increased attention, that produced a greater vividness of the task at hand, leads to its more efficient execution" (109).

Travis (33) finds that a disturbed attention increases, under certain conditions, the acuity of audition. He makes three successive determinations of the *O*s' stimulus-limens to a tone of constant pitch. He determines the limens (1) under normal conditions with attention upon the incoming tones; (2) under distracted conditions with attention on certain tasks (the solution of mathematical problems, memorizing poetry, or the reading of scientific or literary prose); and (3) under normal conditions with attention again upon incoming tones. The limens under (2) are, with few exceptions, lower than under (1) or (3). The decreases in the limens occur with tasks that

the Os found "interesting and enjoyable"; the few increases occur with tasks that the Os "thoroughly disliked" and "failed to get into." Auditory acuity seems, therefore, to vary with total absorption, and not with attention to the auditory phenomena. The explanation that Travis offers of the intensifying effect of attention is reported in the section on Intensity.

Fearing (9), after a brief review of the literature upon distraction, reports the results of his study on attention and body-sway. He has 120 Ss; 60 in each of the control and distraction series of experiments. The Ss are instructed in the control series to direct their "attention towards trying to stand as quietly as possible"; and in the distraction series, during which a Wundt sound-hammer, tapping at the rate of 120 strokes per min., is sounded at irregular intervals, to give their "attention wholly to these taps and count them silently." Fearing finds that body-sway, as measured from the S's head with his feet in the Romberg (heels and toes touching) and 45°-angle positions, is less in the controlled, *i.e.*, distracted, condition than in the uncontrolled condition. That attention alone is responsible for the decreased sway is shown by his statistical treatment of his data.

Sterzinger (30), after a critical review of the tests that have been prepared to measure the ability to distribute attention, reports the results of an experiment in which he requires his Ss to add continuously and at the same time to listen to the reading of a short story. The experiment lasts 1½ min. The columns of figures are so arranged that every addition can be checked. Immediately after the reading of the story, the Ss write their reports of it, being allowed as much time as they require. Every story (there are four) contains 36 items. The number of items reported and the number of correct additions are compared with the number obtained in the separate performance of the two activities. In the light of his results, Sterzinger points out the need for eliminating practice (particularly when attempting to measure the influence of maturity upon the ability to distribute attention), and also the difficulty of determining whether one is really dealing, in such experiments, with simultaneous attention or with a series of rapid shifts of attention.

Ponzo (24) attempts to obtain a criterion from the shifts in attentional fixation that will have significance for the diagnosis of attentional disturbances. He assumes that any deviation in the direction of attention from the normal will have diagnostic value. The normal S can maintain his attention upon the object looked at even when his eyelids are closed passively by the experimenter and

opened again, but this ability is easily lost. In numerous abnormal states the Ss are unable to sustain their attentional fixation. They find, in such experiments as the one mentioned that their attention has shifted to something other than the object previously fixated. This may be due, Ponzo thinks, to the forgetting of the instructions or to an unstable attention. He also thinks that eye-movements, unconscious twitchings and reflexes, may play an important rôle. In order to discover what effect the eye-movements may have upon the attentional shifts, the author employs the campimetric method. He uses a white background, and a black square, 1 cm. on a side, as the stimulus. He made 10 determinations with every S (he used 15, among whom were normal and abnormal, children and adults) of the size of the external horizontal meridian of the right eye. The determinations were made rapidly one after the other, and in no case was the lapsed time between the first and last greater than 5 min.

The Ss noted two opposite tendencies during the course of the measurements: (1) a perserverative tendency—a tendency to follow the instructions to attend to the point of fixation; and (2) an anticipatory tendency—a tendency to neglect the point of fixation and to attend to the appearance of the stimulus. Ponzo finds that these tendencies and the slight reflex eye-movements are sufficient to explain all the variations in his findings. He says that while his experiments were too few in number to permit him to generalize, they are sufficient in number to indicate that the method can ultimately be used in differentiating Ss with respect to constancy and type of attention.

(h) *Accommodation and inertia.* Mager (20) attempts to determine the time it takes to shift attention from one task to another. His problem involves the measurement of the inertia of attention to the first stimulus, and of accommodation of attention to the second. In order to obtain the real time that it takes to turn the attention from the first to the second stimulus, he finds that he has to subtract the time it takes to apperceive or judge the first stimulus from the total time—a procedure which other experimenters have neglected with the consequence they obtained times that were too long. While he can measure the time between the appearance of the two stimuli, he has to depend upon the Os' reports to tell how the second stimulus affects the attentive process aroused by the first. By a method of bracketing he is able to determine the time interval at which the second it attended to without overlapping the first or without there being a gap between it and the first. His procedure is as follows:

The Os have to judge visual or tactual intensive differences, or the number of visual or tactual stimuli presented in the first exposure, and also the number or intensive differences of visual or tactual stimuli presented in the second exposure. The second exposure follows the first after intervals of 0.2, 0.4, 0.6, 0.8, 1.0, or 1.2 secs. The Os report after the presentation of the second stimulus whether it appeared (1) while he was still engaged with the first, (2) after a pause, leaving a gap between the first and the second, or (3) continuously with the first, without overlapping or a gap. Only the third type of report gives measures of time it takes to shift attention from one task to another.

Mager finds that second stimulation overlaps the first at intervals of 0.2 sec.; that it overlaps 50 per cent of the time at intervals of 0.4 sec.; and that it does not overlap or disturb the first at intervals of 0.6 sec. An elaborate treatment of results leads the author to the conclusion that the smallest time in which the attention can shift from one activity to another is 0.190-0.027 sec. Another important conclusion is that the time required to pass from one activity to another is independent of the material or sense modality to which attention is directed. The theory advanced by Mager to explain his results is a restatement of the inhibition theory.

3. RELATION TO OTHER PHENOMENA

(a) *Intensity.* Travis (33) rejects the teaching of current psychology "that attention upon a stimulus increases the intensity of the stimulus, while distraction decreases the intensity" (142), as being contrary to the results of his experiment with auditory acuity and concentrated and distributed attention. As reported above under the section on Distraction and Distribution he finds that the stimulus limen is lower during the performance of certain mental tasks than when attention is directed to the auditory stimulus. His results "indicate that the function of attention, rather than the direct object of attention, is requisite for heightened acuity and to attend to something else would be more conducive toward hearing the faint sound than to attend directly to the sound itself. This apparent contradiction might be explained by the fact that if heightened sensory acuity during the performance of a mental task indicates complete absorption in that task, then just attending to tones is not sufficient to bring about a state of complete absorption and hence not capable of producing maximal sensitiveness of the organism. . . . Thus

it appears in the last analysis that the *degree* of attention determines the liminal values of a stimulus regardless of whether the stimulus is the object of primary attention or some other object that may come under the direction of attention." Travis suggests, by way of explanation, that there may be in attention a reciprocal innervation process which spreads to all sensory fields causing a generalized heightened acuity.

(b) *Learning.* Roberts and Farnsworth (26) describe a piece of apparatus that they have devised to study the attentional phase of learning which they feel is a much neglected phase of the learning problem" (275). They call the apparatus which is a kind of pegging board "an attentional learning board." A problem (of which there is an unlimited variety) is set, and the rapidity with which it is solved is dependent upon the S's attention to details.

(c) *Movement.* Sengupta and Sinha (28) find that performance of the Ss in a cancellation test, employing a voluntary activity, is better under distracted attention, *i.e.*, under the distraction of group environment, than when the Ss work in isolation and are able to concentrate their attention upon the task at hand. Fearing (9) obtains similar results with an involuntary activity, *i.e.*, static equilibrium. He finds that the amount and the variability of sway decreases with distracted attention. His Ss swayed the least when their attention is directed to the sounds and the counting of taps of a sound hammer. They swayed most when they gave their attention to "standing as still as possible."

4. TECHNOLOGICAL

(a) *Attention tests.* The tests of distributed attention that have been proposed by various authors as occupation aptitude tests are reviewed and criticized by Sterzinger (30) in the experiment reported above under the section Distraction and Distribution. Sterzinger points out that the two activities between which the attention is distributed should be separately tested, that the effect of practice should be eliminated, and that the test results are significant only in so far as they test specific abilities.

Rittershaus (25) used with slight modifications the cancellation test as a test of the fluctuations of attention. He applies it to normal and abnormal Ss and discovers that whereas he is unable to diagnose mental diseases, he is able to differentiate certain symptoms.

Ponzo (24) seeks to obtain a diagnostic test of attentional disturb-

ances by means of the campimeter. Variations in the range of peripheral vision are sufficiently affected, he feels, to differentiate Ss with regard to their constancy and type of attention.

(b) *Advertising*. Nixon (21) reports two studies on the relation of attention to advertising. One deals with the attention-value of pictures of people, the other with the attention-value of color. His method consists, in general, in presenting two advertisements simultaneously, only one of which possesses the feature being tested, and in observing the length of time the Ss looked at each. He has thirty-four advertisements with pictures of people, which are paired with a similar number with pictures of objects; and he has forty-four advertisements printed in color which are paired with a similar number printed in black and white. All the other factors of attention that might be effective are balanced in the two series. Every pair of advertisements is presented to each of thirty Ss, varying in age from eighteen to fifty years, for 30 sec. The experimenter, without the Ss' knowledge records the distribution of eye fixations during the time of exposure. Nixon's results show: (1) that pictures of people are effective attention devices; they are superior to advertisements with pictures of objects in attracting attention (first fixation), and in holding attention (average total time of fixation); and (2) color is surprisingly inferior in attention power since it neither attracts great initial attention nor holds it.

Franken (11) summarizes the investigations that deal with the attentional value of advertisements, giving particular emphasis to the conditions that are of significance to newspaper advertisers, and reports the results he obtained in two experiments on the subject. The effect of size and shape, of position on the page and within the paper, of the presence of reading matter, of the reader's reading habits, and of many other factors of special interest to the advertiser are considered. Franken gives in the appendix a bibliography of thirty-four titles, all technological. He neglects entirely the "pure" experimental work that has been done upon the conditions of attention.

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MEMORY¹

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I. MEMORIZING

The Curve of Memorizing. G. M. Peterson (90) has tested the hypothesis that the negative acceleration of the memory curve is, in part at least, a function of the unequal difficulty of the items in the list. The material consisted of pairs of one-syllable words. Lists of unequal items were constructed on the basis of the previously determined difficulty of each item, using two degrees of difficulty. After each learning presentation, the first word of each pair was presented and a record kept of the items memorized in each trial. All records involving the same number of trials were grouped and the means of the hard and easy items learned in successive trials were computed. The majority of the easy items were learned in the early trials, while the hard items were distributed rather equally, resulting in different memorization curves for the two degrees of difficulty. It appears, thus, that the factor of unequal difficulty may account in part for the phenomenon of negative acceleration. It is interesting that a majority of Peterson's curves show a final spurt.

The influence of unequal difficulty appears, in a different way, in the curves for separate items reported by Robinson and Brown (101). In general, these curves evidence the customary negative acceleration, but the sharpness of deceleration varies with serial position. The more favorably situated items show a sharper deceleration. The Robinson and Brown data give an indication of an early positive acceleration in the case of items unfavorably situated in long lists.

Stump (113) finds that, when the number of elements learned in a course in civics is plotted against learning days, a slight positive acceleration appears in the case of the slowest learner, while the curve of the fastest learner shows slight negative acceleration. The

¹ This review is confined to experimental studies. It covers the period since the review by E. S. Robinson, *PSYCHOL. BULL.*, 1924, 21, 569-594.

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Vincent curve for associating pictures of faces with names shows for 12 of Pan's (87) subjects an initial positive acceleration.

Sullivan (114) reports that the curve for nonsense syllables is more regular than those for learning to generalize and for associating syllable names with geometric figures. Renshaw (99) is of the opinion that the uncontrolled shifts in both problem and method which take place from sitting to sitting of an experiment render a memory curve very doubtful of interpretation. Barlow (8) has fitted the hyperbolic equation to the nonsense syllable data of Robinson and Heron and has found that these data follow closely the hyperbolic law.

The Influence of Serial Position. It has long been accepted that the rate of learning of a given item is to some extent conditioned by the place which that item occupies in the series of which it is a part. Reference has already been made to the important finding of Robinson and Brown that items in different serial positions give different memorization curves. This result is but part of a larger study in which the earlier data of Robinson and Heron and of Robinson and Darrow were analyzed to discover the influence of serial position upon memorization of lists of numbers and of nonsense syllables. This study should be considered in connection with an earlier paper by Welch and Burnett (127), in which the direct value of primacy is questioned. These authors find that, when the subject is instructed not to "think backward" during the exposure of the series, the effect of primacy disappears. They suggest that the alleged advantage of primacy may have resulted, in other experiments, from lack of control of the tendency to rehearse the earlier members as the later ones were being exposed.

The experimental technique used by Robinson and Brown largely controls the factor of rehearsal. The exposure rate was 2 sec. per syllable and the subject recited the items aloud before they appeared, if possible. With this technique it was found that the advantages of both initial and final positions are pronounced, and that primacy is consistently a stronger factor than finality. Further, the primacy effect spreads over more items than does the finality effect. This holds, in general, for lists of widely differing lengths. Robinson and Brown suggest that, since Welch and Burnett's subjects recalled immediately after each exposure, their results can be explained in terms of the greater interval, in the case of the initial syllables, between memorizing and recall.

Jenkins and Dallenbach (54) have worked over the results of a previous experiment in which lists of 10 nonsense syllables were learned with a 0.7 sec. exposure time, which would make rehearsal still more impossible than in the Robinson and Brown experiment. The two subjects give divergent results, but the authors conclude that the primacy effect, when it occurs, is explained by an "initial set" toward the first syllable, as evidenced by the tendency to repeat the first syllable first, a tendency favored by the prevailing serial mode of presentation. The instructions of Welch and Burnett against rehearsal probably destroyed the initial set toward the first syllable, and established a set toward the last item instead. It should be noted that this experiment is concerned with recall after intervals of from 1 to 8 hours, while the Robinson and Brown and Welch and Burnett experiments deal with learning primarily.

Primacy and finality are favored positions in Lüdeke's (69) longer series of consonants, as they are in Sullivan's (114) nonsense syllable lists, and Bergeman (12) finds that, in the reconstruction of rows of Rubin figures, these are the optimum positions. Burt and Crockett (21) report that finality is advantageous, while primacy has a greater value with sophisticated than with naïve subjects. A regressive order of syllable perseveration appears in Prandtl's (94) results, and Wylie (137) finds that the initial and final positions are advantageous for symbol recognition. Rehearsal has probably been possible, and some form of social presentation has been used, in these experiments, however.

Whether the explanation lies in rehearsal, "initial set," Woodworth and Poffenberger's suggestion of greater freedom from associative inhibition, or in the varied conditions of the experiments themselves, the initial serial position has a well attested advantage in learning experiments as they are usually conducted. The finality or recency values are likewise high, and the items appearing between the initial and final positions are lower in value than are items in either of these positions.

Frequency and Vividness. In the experiment designed to eliminate the frequency advantage of the initial syllable, Welch and Burnett also studied frequency and vividness. The former was provided by repetition of a syllable in a series and the latter by a small picture beside the syllable, by colors and the like. These factors, as well as primacy and recency, have a recall value superior to the unweighted syllables. Shaffer (107), likewise, finds frequency to be

of high importance in learning logical material, and in Gamble's (32) extensive study of her own nonsense syllable learning, frequency of presentation makes somewhat more difference than does either rate or length of series. Adams (2), however, finds that the recognition value of advertisements may be lowered by repetition beyond the original showing. This suggests the recent statement of Dunlap regarding the negative effect of frequency, at least in learning of the sensori-motor type.

Length of Series and Rate of Presentation. In learning nonsense syllables by the method of right associates, Gamble (32) reports that the difficulty does not increase in proportion to increase in series length, to rate or to number of presentations. The drop in right cases is not sharp, even when the rate is .75 sec. Her work points to important interrelationships between the variables of length, rate and frequency. Meuer (80) read monosyllabic words to his subjects and found that, with a constant reading time, the number recalled showed a negatively accelerated increase with the length of the series. In Ruschel's (103) experiment with digits and syllables as materials, learning shows a negatively accelerated increase as presentation time per element increases from 1 to 6 seconds.

Remote Association. Cason (24, 25) has attacked the problem, originally set by the work of Ebbinghaus, of remote associations in both the backward and the forward directions. When nonsense syllables and words are learned by rote and tested for backward association, it is found that such associations are formed in a ratio of 2 out of 3. The principle of backward association is thus true as a practical proposition in rote learning. This is ascribed to the occurrence of some practice in the backward direction during learning in an apparently forward direction. In a second part of his experiment, logical material was used. Not only did no backward association appear, but inhibiting associations were apparently formed, which interfered with learning in the reverse direction. These results point to the specific nature of serial association.

Garrett and Hartman (33) have studied the same problem with syllables exposed at the rate of .8 sec. per syllable and learned to complete mastery. Again the results of Ebbinghaus are confirmed, although the conditions do not warrant a conclusion regarding the status of such remote associations.

Cason (24, 25) has studied remote forward association with easy and difficult prose and with poetry, testing for remote association

with word lists derived from these materials. The results are not uniform, but the general tendency, even with very favorable testing conditions, is negative to remote association. Sometimes there is even an inhibition of such association. This confirms the result of his previous study that, in serial learning, associations are not remote or indirect, but are highly specific.

Certain factors which may have accounted for the results of Cason, and of other experimenters, are offered in a paper by Hall (43). She points out that logical material, with indeterminate previous associations, was used; it was presented to the subject simultaneously; the testing materials were removed from their original positions in the series; overlearning was great, and the testing was done shortly after learning. In her own experiment, Hall used nonsense syllables learned by the anticipation method, and in making up her test lists no syllable was removed from its original place in the series. Remote associations were looked for between alternate items. The control lists were composed of items from much more remote positions. There appears no evidence for remote association when relearning is immediate, but the test lists are much better in relearning after one week. Hall concludes that remote forward associations are facilitated, within limits, in proportion to the length of the period of forgetting allowed before testing.

In experimentation on remote associative tendency the methodology is peculiarly important and very difficult. The divergence among the methods used in these experiments is sufficient to make conclusions uncertain. Hall's work has avoided many of the difficulties, but there is, for example, a particularly great opportunity in her experiment for an undetermined amount of retroactive inhibition, which may have affected the outcome.

Whole and Part Methods. Brown (19) has repeated Neumann's 1906 experiment, using combined auditory and visual presentation with vocabulary lists of 12 English words paired with two-syllable nonsense words. The data confirm Neumann's finding that even with unassociated elements, and a test order different from the learning order, the whole method has a distinct advantage, if rate and number of presentations are kept constant. In an experiment performed by Meyer (81), in which the subject recited the material aloud, under instructions to avoid harking back to difficult places, the whole method was better for learning nonsense syllables, prose and poetry. The subjects were permitted to break the materials into

parts as they desired. Meyer observes that the two methods elicit different kinds of behavior. With part method instruction, the subject tended to read hastily and impulsively, attempting recitation often after a single reading. With whole method instruction, the reading was slower and the attack was more methodical.

Winch (132) finds that, with subjects of ages eleven and twelve, the whole method has a slight advantage, or is equal to the part method, when the poetry learned is continuous, meaningful and rhymed. With a long and disjointed poem, the part method is the better. In his experiment the part method has a slight superiority. The relative advantages of the two methods is, according to the work of Sawdon (104), a function of the nature of the material. The whole method is superior, for average boys between ten and thirteen, with easy, rhythmic and meaningful poetry, but this advantage disappears with difficult material, disconnected material and lack of rhythm. Sawdon makes the interesting suggestion, also, that the relative merits of the methods may be related to total learning time. For short times the part method may be the better; for intermediate times the methods may be equal; while for longer total times the whole method may be superior, until a period of diminishing returns sets in. The work of Winch and of Sawdon indicates that the nature of the material and the total time involved are important variables in the part-whole problem.

Reed (98) has worked over the data on this problem prior to 1925 and finds the facts less favorable to the whole method than has generally been thought, especially by textbook writers.

Distribution of Study. In an experiment by Gordon (37) three different arrangements of spaced trials were compared with the unspaced memorizing of the Athenian Oath. The concentrated readings were slightly more advantageous in immediate recall, but in a second, delayed recall the spaced readings were the better. Distributed practice was much more effective than massed practice in the word-recognition learning of the young children who were Meek's (78) subjects. The optimum interval between practice periods was, in general, not more than one or two days. Recreation periods introduced between the different series of a word-learning experiment lowered the results, according to Meuer (80). He attributes this to the excitement caused by play. Longer rest pauses were beneficial.

The Influence of Sensory Modality. Worcester (135) has compared visual and auditory presentations of meaningful material. The

methods are roughly equal in rate of learning, but the auditory method gives the better retention. Lüdeke (69) reports that a mixed visual and auditory method is better for learning series of consonants than the visual method alone, and Balser (7) finds that visual presentation of objects and words is better than auditory presentation with most subjects. Auditory memory span is more affected by weather conditions than is visual memory for nonsense syllables (Bethel, 13). In learning figures and syllables, Ruschel's (103) methods gave results in the following increasing order of efficiency: reading aloud to the subject, copying by the subject of an exposed series, silent reading by the subject, and writing from dictation. The differences between the methods are small, however, and their statistical validity is unknown. There is a slight advantage for studying aloud over the other methods used by Seibert (106) in a study of the learning of French vocabulary. In this connection may be mentioned Anibel's (5) comparison of the lecture-demonstration and individual laboratory methods of teaching high school chemistry. Measured by immediate recall the two methods are about equal.

Logical vs. Rote Memorizing. Reed (97) has demonstrated the efficacy, for memorizing, of material with high association value. The memory span for words in sentences is four times as great as for disconnected words. Prose which arouses familiar associations requires less than half the time for memorization than does prose not arousing such associations. The familiar "Marble Statue" passage was reproduced immediately four times better than a passage from Hume. Klemm and Olsson (61) report that verbal prompting is much less effective in the learning of series of 4-place numbers than is prompting in terms of some mathematical relation between the numbers. Key's (60) learning values for words with commonplace relations from the Kent-Rosanoff list are from one and one-half to two times as great as for words with unique relations.

In a comparison of notional and rote memory, Jones and English (57) read to their subjects a simple Chinese story and asked for immediate reproduction. Upon completion of this, the subjects were asked to learn the passage verbatim. The two series gave divergent results; the correlation between them was 0.328. The authors interpret this as putting the burden of proof on the opponents of the Bergson-McDougall hypothesis of a true memory distinct from mechanical habit.

The Influence of Context. Pan (87) has investigated systematically the influence of various word-contexts upon the learning and recall of pairs of logically unrelated words. A word-context logically related to the response word exerts a beneficial influence on learning. When the context is varied during learning, the effect is diminished, and when the context is logically unrelated to both the stimulus and the response words, it is detrimental to learning, as is a word-context logically related to the stimulus word. A context logically related to both stimulus and response words facilitated learning to about the same extent as did a context related only to the response word. The pictures, colors and other devices used by Welch and Burnett (127) to produce vividness in connection with nonsense syllables may be construed also under the head of context. Such context assisted learning.

The Rôle of Form. The effectiveness of a high degree of formal character in a series to be memorized has been demonstrated by Guilford (39). Series of numbers arranged in some form of progression were compared with corresponding series lacking formal character. This type of form greatly facilitated learning. It takes precedence over the individual members of the series and their interrelationships. Guilford believes that this technique approaches more nearly a case of normal human learning than do series of nonsense syllables learned by sheer repetition. The previously mentioned work of Klemm and Olsson is also in point here.

The Influence of Intelligence. The brighter students in Anibel's (5) experiment profit more from the lecture-demonstration method of teaching high school chemistry than do the less bright, and Brooks (18) notes that there is a low correlation between intelligence and transfer of training from substitution to French vocabulary and immediate memory. According to McCaulley (75), mental development varies directly with the ratio of the reverse to the forward memory span, and Lindworsky (68) states that the lower grades of mental ability are unable to facilitate learning by grouping material into large complexes. Lemmon's (67a) regression equation shows that memory and learning are from two to six times as important as factors in intelligence as is reaction time. It is argued that conduction speed may, in part, determine the level of learning ability.

Renshaw (99) finds a low correlation between Army Alpha and the number of sittings required to master the sequence of a shuffled deck of fifty-two cards. The cases of phenomenal memorizing,

to be discussed in a later section, in which a relatively low intelligence level is coupled with a highly specialized memorizing ability, have indicated that this ability is a function of special method, interest and similar factors, and is not a case of high general memorial ability coupled with low intelligence.

Age Differences. The results upon the problem of age differences in learning performance are traditional in their implications, for the most part. Bergeman (12) opens a new question in his discussion of the customary result that memory ability increases with age in relation to the findings of Jaensch and others that the eidetic disposition declines with age. He uses the reconstruction method with rows of Rubin figures. The ability to reconstruct this material mounts irregularly from nine to eighteen. The eidetic disposition for the same subjects falls from twelve to eighteen. Bergeman concludes that the loss of the eidetic disposition is compensated for by formal education and training. Those younger children who do not possess eidetic ability are unable to use other aids; the older subjects could use such aids.

Abramson (1) reports that the capacity of boys for observing and reporting on objects increases progressively from eight to thirteen and fluctuates from that point to age eighteen, with the highest point at age sixteen. With this result Makuch's (73) age curves for syllables, words, phrases and verses, which rise irregularly from eight to seventeen, agree. Pfahler's (92) results from reports on an event show both quantitative and qualitative age changes. Enumeration characterizes the younger children, and interpretation the older. The influence of suggestive questions grows less with age. Pyle (96) finds distinct age increases in ideational learning, and McCaulley (75) reports that memory span is dependent on age. Meek's (78) data on the relatively slow learning of young children imply a similar conclusion for word recognition, and Ruschel (103) states that immediate memory performance for figures and syllables increases slightly from thirteen to twenty. There is little doubt of the general increase of learning ability with increasing age. The lack, however, of studies of the changes in this ability beyond the age of twenty is worthy of note.

Sex Differences. The boys who were Pyle's (95) subjects did better than the girls in ideational learning of material of a scientific nature. The girls excelled in learning material about furs and the animals from which they came. In rote memory there was no differ-

ence between the sexes. It appears that these differences are, in part, a function of the interests and already formed associations which the subjects brought to the material to be learned. In another experiment, Pyle (96) finds that the sexes are less different, after the age of ten, in ideational than in motor learning. Bird (15), investigating the influence of the press upon accuracy of report, discovers but a negligible difference between the sexes.

The Influence of Tobacco, Alcohol and Organic Conditions. As a part of his careful study of the influence of pipe-smoking, Hull (49) has studied the effect on memory span and associative learning. The non-smokers show a distinct loss in memory span efficiency as a result of smoking, a decreased efficiency which extends for a considerable time after smoking. Habituation to smoking reduces this effect about one-half. In associating geometrical figures with nonsense syllables, non-smokers show a loss in learning rate of about 9 per cent immediately after smoking, with recovery after an hour. The habitual smokers show a similar loss and recovery.

Hollingworth (48) has obtained some indication of a detrimental effect of alcohol on the learning of paired associates, although the result is not certainly established. Paulsen (88) finds that memory span and the learning of paired associates are improved slightly by treatment for intestinal toxemia.

The Influence of Hypnosis. In Young's (138) investigation of performance in the hypnotic state, no significant differences appear between the normal waking and the hypnotic states in memory span, adjective-noun paired associates, unrelated words and logical associations. This holds for both learning and retention. That no differences appear in these performances leads to the conclusion that in bettering present memory hypnosis can do little or nothing. In a later paper (139) this conclusion is supported by additional evidence, and it is shown, further, that memory for long past events is much better in hypnosis than in waking.

The Influence of Loss of Sleep and Fatigue. The effect of two days and nights without sleep was, in Weiskotten's (126) experiment, detrimental to the learning and retention of nonsense syllables. The decrease was more noticeable here than in addition and cancellation. Shelley and English (108) have repeated Morgan's work on the influence of fatigue on learning, using Morgan's German-English word lists. In all, 850 pairs were learned. Memorizing capacity suffered little from continued exercise and an end spurt appeared in

the last section of the three hours of study. The authors conclude that the learning of paired associates does not act as a test of fatigability or of fatigue. However, the criticism brought by Robinson against Morgan's work that the influence of practice was not eliminated, holds likewise against this experiment.

The Influence of Muscular Tension, Prior Activity, and Movement. Muscular tension, produced by squeezing a hand dynamometer continuously at a constant pressure, has been found by Bills (14) to be a much more effective condition under which to learn nonsense syllables than the normal non-tension condition. The same result emerges when paired associates are used with a constant learning time. Whitely (128) finds that neither the physical activity involved in four to five minutes of calisthenics, nor the mental activity involved in mental multiplication, when either is introduced prior to learning, has any observable influence on ability to learn word lists. Whitely (129) has also shown that the arousal of an apperceptive system does not significantly influence the succeeding learning. If anything, the influence of a congruous apperceptive system is detrimental to learning. Warden (119) reports that the factor of movement brought into the learning situation favors the immediate reproduction of digits, letters and designs. Movement was introduced by successive exposure accompanied by the movement of a blank card drawn across the face of the card bearing the material, and by drawing the material on glass before the subject.

The Nature of Improvement. Gates and Taylor (34) have made a significant inquiry into the nature of the improvement resulting from practice in immediate memory for digits. The two groups of children employed were equated in sex, age, M.A., I.Q., scholastic maturity and in seven immediate memory tests. The experimental group, which was given practice with digits on each of 78 days during a period of 4.5 months, showed a marked gain in ability as a result of practice. The unpracticed control group was better after 4.5 months than at the beginning of the experiment, but was clearly inferior to the experimental group. After 4.5 months of no practice, the two groups were again equal, not only in immediate memory for digits, but in other immediate memory tests. After 3.5 additional months without practice, both groups were given 22 days of intensive training. At the end of this period the groups were still equal. The results of the 78 days of practice on the part of the experimental group appear to have given them no permanent advantage. The

interpretation is that the improvement from practice is not an improvement of underlying capacities, but is the result of the acquisition of special techniques, adjustment to and familiarity with the experiment. These factors seem to be transitory and unstable, since after 4.5 months they had disappeared. The results of this experiment agree closely with those of the same authors' study of the nature of improvement in a motor function.

Transfer of Training. Woodrow (134) has demonstrated that the amount of transfer is markedly affected by the type of training given. A practice group of college students given routine drill, and a training group given drill plus instruction in the technique of memorizing, were compared with a control. The first two groups worked a total of 177 minutes twice a week for four weeks. The training group was distinctly superior to the practice group on each of six end-tests which were intercorrelated to an average extent of 0.38. The undirected drill produced amounts of transfer which were sometimes positive and sometimes negative, but always small. Directed training with the same drill material resulted in a uniformly large positive transfer. In an experiment by Meredith (79), a group given incidental training in defining words in connection with a study of magnetism, a group trained in critical analysis and defining, and a control group were compared with respect to transfer to a series of end-tests in definition of ordinary words. The first and last groups do somewhat worse on the final end-tests, but the group given specific training in defining and in critical analysis of definitions shows clear positive transfer, presumably, the author writes, in terms of consciousness of method.

Guilford (39) notes that form, once experienced, emerges more readily in a series possessing new members. Pfahler (92) reports that accuracy of testimony can be increased by training in observation, a conclusion with which Winch (133) agrees. Brooks (18) finds no transfer from training in substitution to French vocabulary and immediate memory, nor from mental multiplication to memory functions. To functions having little in common with the trained functions there is little spread.

Memory Span Studies. Guilford and Dallenbach (40) have collected from the literature twenty-seven methods of determining the efficiency of immediate memory. These methods have no accepted underlying principle. The authors attempt to supply such a principle by applying the psychophysical method of constant stimuli to

immediate memory data. In an intensive experiment with five subjects, series of 6- to 12-place numbers were presented, with 100 series for every length, in a chance order. Grading was "right" or "wrong," and the memory span and degree of "precision" were computed from the "right" cases of each subject. The limens vary from 6.713 to 8.592. The experiment was repeated with 100 subjects, using 4- to 13-place numbers. The limen was 6.713, h. was .446. The advantages of this method are: the memory span is unequivocally defined in terms of the accepted principle of the limen; an exact determination may be obtained quickly; all reproductions are taken into account; weights and other complications are unnecessary; single representative values with known "precision" are obtained; and comparisons may be made from the point of view of both liminal values and of amounts of dispersion.

Oberly (84) has used this method in a comparison of the spans of "attention" and memory. The "attention span" is short enough to cause grouping of units after a span of five has been passed. The "attention span" limens range from 2.5 to 8, and the memory span limens from 6 to 13.5. In learning lists of 12 syllables, groupings of 3, 4, or 5 are optimum for learning, with a "complex" of 4 being best of all, according to Lindworsky (68).

Lüdeke (69) reports that one visual presentation of a series of consonants suffices for the reproduction of 8, while a mixed visual and auditory method increases this to 8.9. Young (138) states that the memory span is not increased in the hypnotic condition. McCaulley (75) finds the memory span test diagnostic of the complexity of mental organization.

The Reliability of Memory Experiments. There has been no systematic investigation of the reliability of memory experiments, such as has been made by Hunter and his students in the case of the maze experiment. Coefficients of reliability have been, however, reported occasionally and in an incidental fashion. The largest set of reliability coefficients has been given by Woodrow (134) in connection with his study of transfer. His correlations are between end-tests similar in form but different in content. The coefficients are: rote poetry 0.67, rote prose 0.49, facts (substance) 0.48, historical dates 0.60, Turkish-English vocabulary 0.70, auditory memory span for consonants 0.55. Lemmon (67a), correlating either repeated trials or alternate items, obtains the following coefficients: logical memory 0.60, auditory paired associates 0.85, visual paired associates 0.94, and Turkish-English substitution 0.91.

The correlation between the number of exposures required for two 8-syllable lists given a week apart is 0.66 according to Baxter (10); memory for ideas correlated to the extent of 0.78, even when the repetition of the experiment did not occur under exactly similar conditions; and logical memory materials given twice, a week apart, gave a coefficient of 0.76. Shaffer (107) obtains self-correlations of 0.61 and 0.71 for two units of logical memory material.

The reliability coefficients listed have been obtained with widely varying numbers of subjects and under diverse conditions. The striking thing about them is that they are uniformly higher than the coefficients obtained for the maze experiment.

Miscellaneous Correlations. Cason and Cason (23), in a study of certain relationships between nonsense word learning ability and Kent-Rosanoff measures, find a correlation of -0.29 between speed of reaction and accuracy of learning, and one of 0.30 between speed of learning and individuality of response. Other correlations are positive but low. Lemmon (67a) obtains coefficients of correlation of about 0.20 between memory tests and simple reaction time. This correlation decreases as the difficulty of the discrimination increases, becoming negative with the harder discriminations. Seibert (106) reports that time and accuracy in learning English-French vocabulary correlate -0.23 to -0.39 . The three learning methods used show fairly high correlation.

Phenomenal Memorizing. The number of reports of phenomenal memorizers is almost as remarkable as the feats reported. Downey (28) describes a memory stunt demonstrator with an I.Q. of 92.6, who could repeat the numbers of freight trains in the order in which they passed him, a record covering several pages in the conductor's notebook. When tested, the man showed remarkable visual memory span, poor auditory memory and poor logical memory. The secret of his achievement is probably an interest in numbers and the development of habits of grouping them and handling the groups as units. Likewise, the feeble-minded young man whom Thiessen (115) reports achieves his rapid and extensive date and number memory by organization into small systems.

The case reported by Jones (56) has a wide command of numbers in the form of dates, the populations of large cities and the like. He could give such information with a remarkably fast reaction time. His I.Q. was 74 and his memory test performance was poor. The important feature of the case is Jones' analysis of the drive which

has led a man of inferior intelligence to such extraordinary performance. Jones suggests that this performance is a result of compensation for physical, social and intellectual inferiority. Klyssen (62) describes the unusual date memory of a young man who has been blind since shortly after birth. His immediate memory is at average only, and he seems to achieve memory for dates by the use of a unique associative system. The special place, date and event memory of the nineteen-year-old boy reported by Otis (85) does not alter his intelligence score which is low.

Hennig (45) discusses again his own remarkable memory for dates, recounting experiences of 1923, the dates of which he still recalls with accuracy. In a second paper (46) he has discussed further his supernormal memory. It is interesting that none of his five children seems to have inherited his date and number memory.

Renshaw (99) sought to discover how long it would take university freshmen to duplicate the feat of a "memory expert" who could learn to mastery the order of a shuffled 52-card deck in twenty minutes. The average freshman equalled this achievement in 5.25 sittings of twenty minutes each. Two students were able to do it at one sitting. The secret of such learning seems to lie in the learning method employed.

Qualitative Results. Guilford (39) enumerates the steps in the appearance of form in the learning of series of numbers. The emergence of structure proceeds from a mere feeling of regularity or of order to an awareness of the specific relationships of the numbers. Hegge (44) contributes an extended analysis of the memorial devices used by his subject, of the manner in which the materials are localized, and the other means by which she arranges them in meaningful combinations and complexes, and of the characteristics of these combinations. Lindworsky (68) likewise refers to the value of the ability to group learning materials into significant complexes. Oberly (84) reports individual methods of grouping items in a long memory span series. He adds that visual imagery is of little aid in reproducing long series of digits presented by the memory span method. Lüdeke (69) states that auditory presentation of consonants favors total attention and apprehension. In visual presentation the elements are separately perceived and separately reproduced. A mixed method, depending on the attitude of the subject, may reinforce the impressions and bind them together. Foucault (31) analyzes the aids used in the fixation of verbal material and finds that

the idea of the end to be attained and effort toward this end pervade the learning consciousness.

II. RETENTION

The Curve of Retention. In a number of studies the classical Ebbinghaus retention curve has appeared. Burt and Dobell (22) present a forgetting curve for associations between the name of a commodity and a fictitious trade name. When retention is measured by recall after intervals up to four weeks, the typical curve appears. The recognition curve falls more slowly and indicates greater retention than that obtained with the recall method. Wylie's (137) forgetting curve for the recognition of series of 65 Chinese symbols over periods up to two days shows, likewise, the Ebbinghaus form. Tsai's (117) retention curves for paired associates is negatively accelerated, as is Meuer's (80) curve for word retention. Brown (20) finds little difference between recalls of a 48-word list after 8 and after 16 minutes. There is, however, a steady loss from the third to the sixth day, with a reversal after the seven day interval. There is a correlation of 0.56 between interval and amount forgotten when the third recall is subtracted from the first, and of 0.47 when the third recall is subtracted from the second.

Powers (93) has tested, after varying intervals, the retention of the content of high school chemistry. The amount of forgetting over the vacation of three months is great. For longer intervals, forgetting is less rapid. Tests of different types of knowledge within the same field show differential forgetting rates. The retention curves in the waking condition of the experiment by Jenkins and Dallenbach (53) are of the familiar form; in the sleep condition, after a sharp initial drop, the curves flatten out and maintain a constant level.

In an experiment by Tsai (117) with paired associates, three successive trials were given to all groups on the first day of learning. Six succeeding trials were distributed within eleven days according to three hypothetical retention curves: negatively accelerated, positively accelerated and linear. The results are strongly in favor of the mode of distribution with initial frequency followed by a gradual increase in the length of the interval between subsequent trials. Among the various modes of the distribution of relearning trials after the partial learning, the negatively accelerated ranks first, the positively accelerated next and the linear last. Distribution of learning on these assumptions shows similar results.

A few studies have revealed rates of forgetting which are slower than those usually found. McGeoch and Whitely (76) have published retention curves for the Binet object-card after periods of 30, 60, 90, and 120 days. The card was observed for 30 sec., a time too short to permit of more than partial learning. Recall was in both narrative and interrogatory forms, different groups being used for each form of recall. The retention curve for narrative reproduction falls in nearly a straight line from immediate recall to recall after 90 days and somewhat more slowly from 90 to 120 days. After 120 days 45.3 per cent of the material has been forgotten. The curve for answers to an interrogatory falls much more slowly. The largest amount forgotten is 12.2 after 90 days. The curve of retention thus varies markedly with the method of measurement. Neither curve resembles closely that of Ebbinghaus. It is probable that the large amounts retained after relatively long intervals is a function of the memory material used. Stump (113) reports that the retention curves for the content of a high school course in civics fall relatively slowly over a 42-day interval, and the retention of the meaningful material used in Worcester's (135) experiment was high after seven days. Hegge's (44) subject, who is possessed of supernormal memory ability, shows astonishingly high retention values for lists of different lengths up to 350 words after ten days and one year, in spite of probable retroactive effects from series learned in the meantime.

Reminiscence. The phenomenon of reminiscence is a special case under the more general problem of the retention curve. Because of its uniqueness and importance, however, it is treated under a separate heading. Williams (131) has conducted an extensive investigation of certain of the factual conditions of reminiscence, a problem set by the work of Ballard, Huguenin, Brown and Nicolai, who have agreed in finding remote recalls often better than immediate recalls. The work of Williams is concerned with the influence upon this phenomenon of the age of the subjects and the character of the learning material. The age-groups in the first experiment, with poetry as the learning material, averaged in chronological age: 9.6, 12.7, 16.2 and adulthood. In the second experiment, with word lists as material, the ages were nearly the same. The conditions were planned to give about 50 per cent learning for each age-group. Partial learning is obviously a necessary condition of reminiscence. All groups recalled immediately. Delayed recalls were taken after 1, 2, 3, 5, and 7 days. Reminiscence appeared only with the two younger age-groups and

with poetry as learning material. The greater degree of reminiscence, and reminiscence after longer intervals, were shown by the youngest age-group. Within these age-groups, the subjects who learned the least exhibited the greatest reminiscence. Also, the phenomenon appeared to the greatest degree when the material was scored for correct verbal reproduction. The large number of subjects used and the careful controls render the experiment highly significant, both from the standpoint of verification of the occurrence of the phenomenon and from that of its conditioning factors. Reminiscence may be, as William suggests, a special case of the more general principle that retention varies with the material, the method of scoring, the amount learned, the age and sex of the subjects. It may be that degree of learning is the most important factor, since the younger children learned a smaller amount of material and hence had the greater opportunity for reminiscence.

Gordon (37) records the occurrence of reminiscence in about 4 per cent of her subjects who had learned the Athenian Oath, and that it was more frequent with the poorer memorizers. There is a slight reminiscence effect in the recalls of some of the children who were Meuer's (80) subjects, especially with a 10-word series, and there is some reminiscence in the poetry recalls of the 12-year-old boys in Winch's (132) experiment.

The Influence of Interpolated Activity. The phenomenon of poorer retention when the original learning is followed by interpolated learning or other mental activity than when it is followed by relative rest has been verified by Hinrich (47), Jenkins and Dallenbach (53), Lund (71), Robinson (100), Skaggs (110), and Whitely (129). Hinrich has found retroaction with children as subjects, and Lund has observed it with recognition as the method of measuring retention. This finding of Lund's does not agree with the results from Müller's laboratory. Skaggs obtains retroaction with reconstruction of chess patterns, sense words and nonsense syllables. The interpolated work consisted of adding or of reasoning problems. Whitely interpolated between learning and recall either résumés of a given field of knowledge which the subject was to read and answer questions upon, or a question and answer association test. The original learning materials were lists of words or phrases bearing the flavor or connotation of a certain background of knowledge. The arousal of an apperceptive system prior to recall influenced recall detrimentally, both from the standpoint of percentages of recall and from that of percentages of error.

Ebbinghaus was at a loss to explain, aside from experimental errors, the fact that between the 8.8 hour and one day periods the forgetting was proportionately less than during the period between one and two days. Jenkins and Dallenbach suggest that the explanation lies in the fact that sleep filled the greater part of the first interval and a proportionately smaller part of the second interval. They find experimentally that more than twice as many syllables are reproduced by both their subjects after intervals of sleep as after intervals of waking. The sleep condition is superior with intervals of 1, 2, 4, and 8 hours, becoming more pronounced as length of interval increases. The difference between the two conditions is sufficient to account for the Ebbinghaus result. The Jenkins and Dallenbach data indicate that forgetting is a matter of the inhibition or obliteration of the old by the new, rather than a passive decay.

The problem of the influence upon retroaction of the degree of similarity obtaining between the original and the interpolated activities has been attacked by Robinson, Skaggs and Whitely. Skaggs' results corroborate the earlier conclusions of Robinson that, within limits, the more similar are the original learning and the interpolated work, the greater is the retroaction. In both studies, however, similarity was not quantified. It could only be ranked. This general conclusion is supported further by the finding of Whitely that the detrimental effect of congruous interpolation is greater than that of non-congruous material.

Robinson has carried further the attack upon the similarity factor, and has tested the generalization, implicit in current work on retroaction, that there is a region somewhere between identity and zero similarity in which retroaction reaches a maximum, and that it is always less at identity than at zero similarity. In a preliminary experiment, retention of the length of a line turned out to be resistant to retroaction. In three major experiments Robinson has achieved a quantification of similarity using consonants learned by the memory span method. In the first experiment, a list of four consonants and an interpolated list of four were used, making a total list of eight. Any desired similarity between the two sets could be introduced. When efficiency of recall is plotted against the number of identical consonants in the two halves of the lists, the curves fall steadily from four to one. Only in Cycle I does the predicted inversion occur—at the one-identical condition. In this experiment visual presentation was used. In a second experiment, with auditory presentation, the first cycle again shows a first order inversion at one-

identical, which disappears in the second and third cycles. It appears, thus, that practice and familiarity are important factors in the disappearance of the inversion. In a third experiment, with six consonants in each half of the memory span lists, the curves fall as before, but an inversion occurs at one-identical in the fourth cycle. This has the marks of a statistical accident. With this ingenious method of quantifying similarity, Robinson has shown, therefore, that the expected relationship does not hold under certain defined experimental conditions.

The problem of the influence of the temporal position of the interpolated activity has been studied by Whitely and by Skaggs. The data of Whitely's experiment show unambiguously that the influence of an apperceptive set aroused by congruous interpolated material is detrimental to recall, whether introduced prior to recall, prior to learning, or immediately after learning. The detrimental effect was greatest when the set was interpolated immediately preceding recall and least detrimental when it followed learning. The work of Skaggs confirms the importance of temporal position, but differs from Whitely's results upon the point of interpolation which gives the greatest amount of inhibition. He finds that the introduction of work immediately after the original learning is more detrimental than when it is introduced after a rest interval.

A few studies, using different experimental conditions, have revealed either no retroaction or a facilitation effect. Whitely (128) reports that short periods of mental and of physical work introduced prior to the learning of lists of words does not influence recall after 24 hours, neither is it detrimental when interpolated prior to the recall of material learned under normal conditions. Whitely and McGeoch (130) have studied the influence of the interpolation of an interrogatory form of report immediately following a narrative report upon the same material. The Binet object-card was used. Recalls were taken after 30, 60, 90 and 120 days. The interpolated interrogatory recall has a facilitating influence upon subsequent narrative recalls, particularly after 90 and 120 days. A narrative report interpolated prior to the interrogatory recall neither facilitates nor inhibits the recalls in answer form.

Distribution of Study. Tsai's work on the various forms of distribution has been discussed in connection with the retention curve. Worcester (135) concludes that one repetition after one day so strengthens well learned material that there is no marked decrease in amount retained during the next day, and a second repetition after

two days is sufficient to insure a high degree of retention for at least a week. Related to this is Seibert's (106) finding that frequent relearning slows the forgetting of French vocabulary to a great degree.

Massed practice is better than the other methods used by Trow (116) for retention of rote material over a period of one day, but it is useless for retention over longer periods. It is as good as any of the forms of distribution used for brief retention of meaningful material. Burt and Dobell (22) find that, in memory for advertising material, distribution in the form of an early follow-up is more effective than in the form of a later follow-up. Widely distributed trials give, with young children, a smaller loss in ability to recognize words than do massed trials (Meek, 78).

Whole and Part Methods. Sawdon (104) records that, with poems that are easy to understand and that are possessed of pronounced rhythm, the whole method is even more advantageous for retention after a month than for immediate retention. This is in agreement with Meyer's (81) statement that the whole method of learning nonsense syllables gives, after short intervals at least, better retention than does the part method. Meyer's results for poetry are inconclusive.

Length of List and Amount of Material. Balser (7) has verified the conclusions of Michel and of Meuer that the number of elements retained varies with the number presented, although not in direct proportion. The exposure time was constant at 10 sec., and the number of elements varied from 5 to 20. Lüdeke's (69) shorter lists of consonants, learned by a form of the memory span method, resisted the longer intervals between presentation and recall better than did the longer lists. In Washburne's (125) study of the recall values of various methods of presenting quantitative material, it was found that a simple visual pattern and few data favored specific recall, while the more complex the pattern and the more numerous the data, the more general the recall. An increase in the number of data shown in a graph affects unfavorably the recall of specific amounts, but does not thus affect the recall of static and dynamic comparisons. In Schmidt's (105) study of advertising, increase of materials led to more errors of recognition. Adams (2) finds, however, that a word isolated on a page has no greater recognition value than two or four words per page.

Methods of Presentation. The recall values of several methods of presenting a constant amount of quantitative material have been compared by Washburne (125), using large numbers of subjects. The paragraph is least favorable to the recall of quantitative data, whether general or specific. The line graph is most favorable to the recall of relative increase, decrease and fluctuation. The statistical table is the form most favorable to the recall of specific amounts. For simple data some form of the pictograph, and for complex data the bar-graph, are the most effective, when recall is of relative amounts. Little difference is found by Garrett and Hartman (33), in terms of savings score, between the continuous (simultaneous presentation) and the discrete (successive presentation) methods of learning syllables. Seibert (106) obtains better retention of French vocabulary when the subjects learn it aloud, and retention is better, for the meaningful material used by Worcester (135), with the auditory than with the visual methods of presentation. Some of the other papers discussed under the influence of sensory modality on memorizing are also in point here.

Methods of Reading and Note-taking. With groups equal in intelligence, intensive reading gives reproduction scores superior to those resulting from extensive reading. Retention in terms of solving problems and answering questions is roughly the same for both reading methods (Good, 35). In another investigation, Good (36) finds that, for accurate reproduction of ideas, intensive reading of 44 pages in a text is as efficient as the reading of this amount plus 160 pages on the same topic from related books. Measured by a general quiz after the lecture, the students who take notes recall considerably more than those who do not take notes. This relation is slightly reversed when a true-false test is used. The note-takers are distinctly superior on delayed recall in the form of a general quiz. This superiority is less when a true-false test is given (Crawford, 27). This author (26) also obtains a significant positive correlation between the number of points recorded in the notes and the number recalled on a later quiz.

The Effect of Associative Aids, Perceived Relations and Context. The work of Reed (97) points the importance of association for retention. Prose which aroused many associations was 15 times better reproduced after a week, and 8 times better reproduced after two weeks, than hard prose with fewer associations. Vocabulary lists of associated pairs were also better retained than lists of unasso-

ciated pairs. A similar conclusion is reached by Klemm and Olsson (61), who compared mechanical aid with meaningful aid. The logical aids yielded superior retention after intervals up to 476 days. Logical factors in the grouping of quantitative materials were found by Washburne (125) to favor recall.

Key (60) has examined the function of perceived relations in recall. The recall value of commonplace words from the Kent-Rosanoff list is from one to three times greater than that of unique words, and the rate of forgetting is about 20 per cent slower for commonplace words. With material consisting of word-pairs constructed by the learners and estimated for closeness of relation, the correlation between closeness of relation and recall is from 0.81 to 0.93. Key's interpretation is that the commonplace, close and freely selected relations are the easily perceived relations.

Pan's (87) study of the influence of context was concerned with recall as well as with learning. The introduction in recall of a context logically related to the response word, when none had been present in learning, exerted a facilitating influence. The removal or interchange of a context logically related to the response word, which had been present in learning, had a detrimental effect, and the removal in recall of a context logically related to both stimulus and response words had a less detrimental effect. The removal of a context logically related to the stimulus word had no observable influence, and the removal of a context logically unrelated to either stimulus or response word was beneficial. These results clearly indicate that recall is affected by environmental factors connected with the material to be recalled.

The Influence of Repetition. Adams and Dandison (3) gave their subjects eight presentations of words arranged in an advertising "dummy." When retention is measured by the numbers recalled and these values plotted against repetitions, the curve for the first four repetitions suggests an approximate root curve. Over the last four points the curve rises again, however. The corresponding curve for recognition shows an initial rise followed by a plateau with no subsequent rise. Lund (71) finds that two presentations of series of 5-letter nonsense words are little better for recognition than one presentation. In an experiment by Keller (59) there is some indication that recognition increases with increasing degrees of learning.

The Influence of Intelligence. Lee (67) has correlated intelligence (NIT, A and B) with scores on four memory tests. Retention

was tested after 30 sec. and 24 hours by both recall and recognition. The correlations between intelligence and retention were all positive, and in some cases were fairly high. Correlation with immediate memory is somewhat higher than with delayed. The amount of relationship varies with both material and method of measurement. The materials yield correlations in decreasing order thus: pictures of familiar objects, words, syllables and geometrical forms. Recall of pictures, forms and words correlates to a slightly higher degree with intelligence than does recognition. Recognition of syllables gives higher values than does recall of syllables.

Abramson (1) states that the more intelligent children recall better the differential features of objects. The less intelligent can, however, recall well the location of objects. According to Brednow (17), cases with intelligence defect show more report errors than do normals. McGeoch (76) has compared, with respect to ability to observe and report, two groups of equal chronological age but differing by at least three years in mental age. One group was normal, the other subnormal. The Binet object-card, a picture and an event were the materials used. The amount recalled was measured by a narrative reproduction, followed by an interrogatory. The range of report was greater for the normals on all materials. The normals show a smaller percentage of report error and attest more items and with a greater accuracy, on both narrative and interrogatory. The correlations between intelligence and report ability show a tendency toward zero or inverse relationship with the normals, and a tendency toward a moderate positive relationship with the subnormals. Zillig (141) believes that the optimum conditions for the production of an unbiased testimony are a combination of high intelligence and low general affectivity.

In Good's (36) work on reading, the upper quartile in intelligence is little better in reproduction of ideas than is the lower quartile. Good suggests that, while the lower students do almost as well as the others in the somewhat mechanical process of reproduction, they do less well in thought-requiring performances. Crawford (26) reports that intelligence is not an important third factor in determining the correlation between notes and quiz grades, and Balser (7) discovers no relation of memory for objects and words with intelligence in fourteen-year-olds.

In this connection, reference should be made to the phenomenal memory feats described previously. A majority of the cases were of subnormal intelligence and had achieved their high level in certain

narrow fields of memory by virtue of special motivation and techniques. There is, thus, in this special class an inverse relationship between memory function and intelligence.

Age and Sex Differences. The correlations computed by Lee (67) between age and retention vary with the materials used and the methods of measurement. In general, recall correlates higher with age than does recognition. The correlations between age and recognition are for the most part slightly negative. The recall of pictures gives the highest correlation with age. Ability to reproduce and recognize objects and words increases at least to age fourteen, Balser (7), and Pfahler (92) has noted both qualitative and quantitative age changes in ability to report on an event. There is some indication in the work of Worcester (135), although the number of cases is small, that increase in age beyond twenty affects retention more than learning. The fact that the greatest degree of reminiscence occurs with younger age-groups has been mentioned in the review of Williams' work. The influence of apperceptive set is not a function of the age of the subjects used in Whitely's (129) experiment.

No significant sex differences appear in recall and recognition of the poster boards used by Burt and Crockett (21) and Wylie (137) finds no sex differences in the recognition of Chinese symbols. Bird (15) obtains negligible differences between the sexes in the influence of the press on the accuracy of report.

The Influence of the Press and the Group. The Minnesota student paper published an incorrect report of certain lectures in psychology and Bird sought to determine the effect exerted by the reading of the report upon later questions about the lecture material. In answer to all questions, the students who had not read the inaccurate report were more accurate than those who had read the account. This was true in spite of certain conditions which seem to have favored a minimizing of the differences. According to Elkin (30), when subjects learn as members of a group instead of individually, immediate memory is better and forgetting is much less. The group influence aids the poor learners least.

Experiments on Testimony. A major part of the data from testimony experiments has been reviewed under other headings. Luetgebrune (70) cites an incident showing the general unreliability of testimony, and Monget and Gelma (82) report a case of judicial error resulting from agreement of wrong testimonies. Pfahler (92) warns against the danger of suggestive questions. McGeoch (76)

finds that the oral and written methods of obtaining the reports of children give equal values in range and accuracy. In narrative reports a small percentage of errorless records appear, but with restricted range. No errorless interrogatory reports were found.

Affective Tone and Retention. Five studies of the recall of affectively toned and emotionally toned experiences have issued from the Vassar laboratory. Washburn, Harding, Simons and Tomlinson (120) selected, on the basis of ratings both by the subject herself and by others, equal groups, one containing those steadily cheerful, and the other those steadily depressed or tending to depression. Three series, each of 50 words not obviously either pleasant or unpleasant, were given to these groups under the instructions to report the idea aroused and its affective tone. The cheerful group recalled by far the greater number of pleasant associations. The same rating system has been used by Washburn, Booth, Stocker, and Glicksmann (123) in a study of directed and free recalls of pleasant and unpleasant experiences. In directed recall the subject was instructed to recall a pleasant or an unpleasant idea in response to a stimulus, and reaction time was taken. In free recall, the subject was free to recall either type of experience. The method of directed recall differentiated the cheerful from the depressed group slightly better than did free recall. Washburn, Giang, Ives and Pollock (121) find that emotional and calm subjects recall joy-producing incidents about equally, but a larger proportion of emotional than of calm subjects recall many angers and fears. Eighty per cent of the subjects who gave galvanometric deflections above the median amount during recall of incidents producing anger, joy and fear were in the group rated as emotional (Washburn and Pisek, 122); and Washburn, Rowley and Winter (124) report that emotional subjects do not recall emotions from more recent dates than do the calm subjects.

Würdeman (136) has performed an experiment in which the subjects were asked to associate objects with odors and to rate the affective values of the impressions. Experiences which are distinguished by great affective intensity are remembered better than are weakly toned impressions. Würdeman discards the notion of the unique associative character of olfaction. Unique efficacy has been attributed to it because of its affective value. In the work of Anderson and Bolton (4), when odors are associated with nonsense syllables, both pleasant and unpleasant stimuli have an advantage over indifferent stimuli in recall and recognition, but there is little differ-

ence between the pleasant and unpleasant stimuli themselves. Gordon (38), however, in a careful study of the recall of pleasant and unpleasant odors obtains no correlation between the memory values of odors and their affective values. She concludes that "we must search for other factors than affective tone if we would understand why some impressions are recalled and others are not."

Stone (112) has concluded, after a study of the influence of a variety of affective conditions, that the affective state of the subject greatly influences his recall, but that large individual differences occur. Zillig (141) notes that testimony is unconsciously falsified under the influence of sympathies and antipathies.

Hypnosis and Loss of Sleep. Young's (139) conclusion that memory for long past events is better in hypnosis, although immediate memory is unaffected, has already been cited. Post-hypnotic tests show that the subject retains at least a part of the hypnotic impressions. He can give in waking associations acquired in hypnosis; and relearning, in waking, material taught him in hypnosis, shows a saving. Insomnia, in Weiskotten's (126) experiment, exerted a detrimental effect on the relearning of nonsense syllables.

Abnormal Phenomena. Brednow (17) presents evidence that children showing *pseudologia phantastica* report upon a picture and a story less well than do normal children. Janet (51) cites cases of patients whose memories are very full, but who have about their memories a feeling of unreality; and also (52) a case of super-real memory appearing without connection with the present and beyond the control of the patient. Koch (64) finds that a pair of Siamese twins agree in varying in the same direction from memory norms.

Memory Types. Rombach's (102) work grows out of an earlier experiment by E. Stern, who distinguished between the memory type which retains without altering the material and the type which elaborates and transforms the material. Rombach's results indicate that the distinction is a valid one and that the types actually represent fairly permanent dispositions on the part of the subjects. Zillig (141) believes that subjects can be classified into two groups on the basis of their susceptibility to falsification of testimony by sympathies and antipathies. According to Schmidt (105), there is a class of persons who have a pronounced inclination toward the making of errors in the recognition of advertisements, an inclination which is independent of general memory performance and of intelligence. In the perseveration of syllables Prandtl (94) distinguishes two types: the

persistent, in which the perseveration continues for some time, and the fugitive, in which the perseveration is rhythmic.

Recall vs. Recognition. In a study of the memory value of advertisements, Brandt (16) finds that recall and recognition give different results, the items best recalled not being those best recognized. Lee (67) working with pictures, words, forms and syllables, obtains in general positive but low correlations between recall and recognition, indicating that the two functions "can scarcely be treated as identical processes, at different levels, with reference to a threshold of retention." Difference in content causes less fluctuation than is caused by differences in testing methods. Burt and Crockett (21), on the other hand, obtain a correlation of 0.71 between recall and recognition scores for poster board advertising. The differences between the two results is possibly a result of the different materials and methods. Certain differences between recall and recognition have been referred to in other connections in preceding sections of this review.

Other Factors Affecting Retention. Under this head will be cited problems upon which but a single experiment is available. The work of Bills (14) upon the influence of tension dealt with both learning and retention. Nonsense syllables learned under the tension condition were the better retained, as measured by both recall and relearning. This advantage tended to disappear with practice. When, however, learning time was held constant at one presentation and sense material used, the recall scores of the tension group were throughout superior to those of the normal group. Zeigarnik (140) finds that mixed series of such tasks as multiplication, printing names, and the like are better recalled when they are interrupted prior to completion than when they are fully completed. Bechtold (11) has compared 50 seeing with 50 blind children, paired in age, with respect to the retention of meaningful and nonsense material. The seeing children do better than the blind with meaningful material, but the blind excel with the nonsense material. Brandt (16) has taken account of the influence of color in advertisements upon retention. Red, yellow and green have a higher memory value than blue by all the tests. The relative position of the colors vary with material and method of measuring retention.

The day-by-day curves of Laird's (66) subjects for immediate memory for words and ideas rise to a high point on Wednesday. The curves for delayed retention reach the highest point on Friday. Over

a single day, retention tends to fall from 8 A.M. to 8 P.M., after which there is a slight rise which does not reach the average of the day. In the work of Mack and English (72), the average reaction time for the eduction of a relation is almost twice as great as for the reproduction of an associate.

Mühl (83) offers the combined methods of crystal gazing and automatic writing as significant methods for obtaining a more than ordinarily complete account of the subject's forgotten incidents. Penrose (89) has studied the influence of suggestion and inhibition upon immediate reproduction. The instruction to reproduce leaving out a given element alters the values of the mistakes made. A Freudian explanation is offered. The suggestion of an alternative form of the characters used, combined with inhibition, produces a greater effect than the sum of the conditions separately given.

The Correlation Between Learning and Retention. Experiments in which immediate recall has been used as a measure of amount learned will be considered under this head, as well as experiments in which learning has been measured in terms of more direct criteria. Gordon (37) and Winch (132) have shown that the degree of relationship between learning and recall is, in part, a function of the learning method. When learning is by the spaced method, the correlation between immediate and delayed recall of the Athenian Oath is higher than when learning is unspaced. The same correlation is 0.829 when poetry is learned by the whole method and 0.936 when it is learned by the part method.

In Lee's (67) study, the correlations between retention tests after 30 sec. and after 24 hours are fairly high. In general, meaningful and familiar materials give higher correlations than materials meagre in associations. Using connected sense material, Peterson (91) obtains correlations of 0.87 and 0.94 between learning and retention, and a coefficient of 0.71 is found by Stump (113) between the rate of learning meaningful material and the amount retained. In Reed's (97) experiment on the influence of association in learning, learning correlates with relearning after 7 and 14 days between 0.35 and 0.75. Brown (20) believes that a positive relation between learning and recall is normal. He finds, however, that the correlation between amount learned and amount retained decreases as the interval between learning and recall is lengthened.

Qualitative Results. Bartlett (9) gives a general summary of an experiment designed to study the influence of repeated reproduction

of stories. The most general character of the series of reproductions was the persistence, for any given subject, of the general form of the first reproduction. Transformations occurred by connection with other material outside of the story, by individual bias or interest, by change of some isolated detail into a more familiar form. Thus the story was robbed of puzzling elements and rendered more understandable.

The degree of confidence which accompanies recognition is determined by the degree of similarity between present perceptual and associative reactions and previous reactions (Lund, 71). According to Lüdeke (69), recognition is based sometimes on imagery, sometimes on indirect criteria such as the almost compulsive character of the associations, the spontaneity, force and precision of the reproduction. Keller (59) believes that in syllable recognition the feeling of unfamiliarity is more than the absence of familiarity, and Wylie (137) also finds a difference between the two. Juhász (58) contributes an analysis of the factors which are important in the recognition of musical triads.

Guillaume (41) discards Abramowski's notion of the persistence of memories in affective form. When names are recalled, they come in terms of sensory elements. Reference has been made to Würdeman's (136) statement that intensity of feeling favors retention. He believes, also, that objects may be confused as a result of common affective impressions, and that the feeling state may survive the recall of the object. Zillig (140) explains the better recall of interrupted tasks in terms of an unresolved tension or "quasi-need." Washburn and Pisek (123) report that emotional persons are somewhat better judges of the intensity of revived emotions, since they experience emotions oftener and at higher ranges of intensity than do calm subjects.

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(To these should be added papers by DE FURSAC and VERVAECK in *Ann. de leg. med.*, 1926, and one by KIRKWOOD in *Iowa Stud. in Child Welfare*, 1926.)

EXPERIMENTAL STUDIES OF THOUGHT AND REASONING

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The present review attempts to cover the experimental literature on thought and reasoning which has appeared between 1922 and 1926 inclusive. It is obvious at once that by confining the review to experimental studies a very considerable portion of the work on thought and reasoning is left untouched. This work falls, roughly, into three more or less different fields. The first of these is the general field of philosophy,—more specifically, the subjects of logic and theory of knowledge. The second of these fields, which has only recently been staked off with some critical insight from the larger tracts of speculative psychology, may best be called theoretical psychology in Lindworsky's sense of the term.¹ In both of these fields one may find valuable contributions to the psychology of the thinking processes. But their point of view and methods of approach create a special subject-matter which calls for separate treatment. The psychology of thought invites, thirdly, much expression of opinion, criticism, and discussion, of which the usual plethora may be found during the period under consideration. The present review, moreover, makes only occasional reference to the literature of intelligence-testing since this subject receives separate treatment.

Out of the experimental investigations considered below there emerge three rather definite and generally accepted conclusions regarding the nature of thought. There are dissenting voices, as will be seen presently. But the degree of indorsement, for such a moot topic, is worthy of note. The conclusions are not novel. Even before the work of Külpe and his students a few psychologists had come to like conclusions. But the accumulation of more factual evidence serves to get these conclusions shaken down into the body of generally accepted psychological doctrine.

1. *Rejection of Associationism.* The sequence of ideas which enter into a train of thought cannot be accounted for in terms of

¹ LINDWORSKY, J. *Theoretische Psychologie im Umriss*. Leipzig: Barth, 1926. Pp. vi+103.

association. The ideas are linked together and directed towards a given goal, but frequency and recency, similarity and contiguity, or any other laws of association, are inadequate to an explanation of the particular kinds of linkage and direction found in thought.

2. *Impalpable Character of the Contents of Thought.* Some of the ideas which accompany the act of thinking present sensory aspects. These ideas may or may not be relevant to the purpose of the act. But there are persistent contents of thought which reveal no sensory stuff whatsoever. A goodly proportion of thought is imageless.

3. *The Steering Principles of Thought.* As a corollary of the rejection of associationism there enters the notion of a selective and directive factor which gives to reasoning and thinking their most fundamental character. This factor still eludes precise description and definition, but the insistence of the phenomena which indicate its operation is very striking.

The most comprehensive, and probably the most important, contribution to the experimental psychology of the higher mental processes during the period under consideration has been the work of Otto Selz (26). In his experiments he used, chiefly, the method of partially constrained associations, with numerous variations of *Aufgabe*, in an effort to get at the factors which guide the course of events in the act of thought. The most crucial phenomenological data, which run their course in consciousness along with the more familiar sensory items, turn out to be impalpable awarenesses of relations and directions. The Os are continually aware that for certain items others, of a determined sort, must be found and that their thoughts are directed towards these missing terms, but this knowledge is rarely given in the form of sensory ideas. The fact that in reasoning only those relational items appear which are in line with the *Aufgabe* cannot be explained by association. Almost any stimulus-word is potentially adequate to the arousal of a large number of associates, but only one particular associate gets singled out. This selective process is not to be conceived of as the exploration of a constellation of ideas, nor as a trial-and-error sort of elimination. On the contrary, it is immediate and direct, and has many aspects which resemble reflex action. The final term in any thought-relationship is not the product of diffuse reproductions among which a choice has been made, but the direct and predetermined response to the first term acting as a stimulus. The process of thought is characterized, then, by what Selz calls reflexoidal coördinations. These coördinations obtain between the terms of thought-relationships, just as a

reflex describes a physiological relationship between stimulus and response. In reasoning the stimuli are ideas, concepts, and what not, together with impalpable anticipatory schema set up by the *Aufgaben*, and the responses are actualizations of these schema. The actualizations which take place in reflexoidal coördinations are susceptible of minute distinctions and classifications. Selz has given a short summary of these in a later monograph (27). Excellent summaries and theoretical considerations of the whole German *denkpsychologische* movement may be found in the works of Hönigswald and Honecker (15, 16).

T. Weiss (41) emphasizes the actualization of the second term in an impalpable knowledge-relation as the most important operation in controlled associations. The presence of one idea can function as the point of departure for the actualization of a second idea only if the relation between the two has been grasped. It is a question, then, not of mere association, but of the reproduction of a relational totality on the basis of a knowledge-disposition. Duncker also lays stress (7) on the relational properties which exist in thinking. In all creative thought there is a definite goal to be reached and a conflict to be resolved before the goal can be attained. No form of association can possibly account for the fact that in a bit of successful reasoning only those aspects of all the possible properties of the problem-situation are extricated which satisfy the demands of the *Aufgabe*. The extrication of these essential properties is conditioned by *insight*, a phenomenal or physiological content determined by intrinsic traits of the problem-situation. These traits are potential formal relations within the situation created by the juxtaposition of conflict and *Aufgabe*. The act of reasoning is completed by the realization of the functional value or relevance of the extricated properties. The inadequacy of association is clearly implied in R. D. Carmichael's paper (3). The author calls attention to the importance of a class experiment performed at Princeton by graduate students in projective geometry under the direction of O. Veblen. The results showed that logical processes may be independent of their mental objects and may be carried on without knowledge of the concrete items of the postulates. Exact thought consists of a set of postulates and the consequences which flow from the postulates by such processes as compel assent to the conclusions reached. Such creative thinking flies in the face of all mechanistic conceptions of mind. It has been shown, nevertheless, (39) that a high correlation exists, in many cases, between control of visual imagery and esti-

mated geometrical ability. Prolific reports on the logical faculties have been made by G. Störing whose separate experimental papers (31, 32, 33) including the one by W. Störing (30), have now been assembled in book form (34). Elaborate distinctions and classifications relating to mental states of validity, assurance, certainty, and the various patterns and sets which lead to conclusions in syllogistic reasoning run throughout these papers. On the basis of the results of an objective experiment on inductive inference (detection of common radicals in Chinese characters) Kuo (19) classifies reasoning into five aspects: (a) reaction to relationship; (b) number of cases upon which inference is based; (c) nature of hypothesis concerning the relationship; (d) discovery of negative instances; and (e) attitude towards negative instances. The author is convinced that the results of the investigation demonstrate the possibility of studying the so-called higher mental processes without using the method of introspection.

"Any disturbance whatsoever in the concrete particulars reasoned about will interfere somewhat with the reasoning, making it less correct or slower or both." Thorndike (35) tested the truth of this theorem, a corollary to the view that reasoning is the organization of habits rather than a special activity, by presenting Os with two sets of nine tasks in algebra. Each pair of tasks demanded the application of the same principle, but the concrete situation in one case was one made more or less familiar by associative habits, whereas in the other the concrete particulars were somewhat altered. The per cent wrong or incomplete for the tasks in which customary associations were favored was 34.4, and for those in which some change was made, 54.2. Tilton (37) also fails to find any clear distinction between the higher mental processes and those of association. He found that the scores of association tests correlate as highly with those of reasoning, judgment, problem-solving, etc., as do any of the latter with each other. Heidbreder (12) placed his Os in completely novel situations requiring a solution. Observation of their behavior led the author to conclude that the solution of a problem is a very definite event in a subject's activity, but that this solution is not effected by a special process or group of processes which may be identified as a complete act of thought. There is no series of events, no set of requirements, no pattern of behavior which represents what actually takes place in thinking. Thinking, empirically defined, is whatever happens when individuals solve problems. The term, then, is applicable to any set of responses which appears during the course of a problem. The

frequency with which verbal responses or imagery have been reported during reasoning led Thorson (36) to investigate the relation of tongue movements to internal speech. Do movements of the tongue occur with frequency during internal speech? Are the movements which occur identical in form to those of overt speech? Are they an essential element of internal speech? To these questions the experiments returned largely negative answers. What, then, is the significance of the movements which are reported and found? The author suggests that the overt movements of the tongue which are observed during internal speech are to be interpreted as mere chance results of neural irradiation, rather than as specific elements relevant to the thought processes. In this respect they resemble drumming with the fingers, facial contortions, tics, etc. There is no indication of a significant correspondence between movements of the tongue and verbal formulations in thought.

Many studies indicate that not only is verbal formulation of thought unnecessary; formulation of any kind in sensory terms is not essential. Rösger's Os insist (24) that between the appearance of a stimulus-word and the determined response there enters a schematic anticipation of the fulfillment of the *Aufgabe*. This anticipation very generally assumes the nature of impalpable knowledge which takes on sensory aspects only when the item which satisfies the formal relation between stimulus and *Aufgabe* actually appears in consciousness. Weinhandl's Os (40) were given incomplete syllogisms and sentences and asked to fill them out mentally. The protocols reveal two unique impalpable experiences: the *Annäherungserlebnis*, which has an active character and is distinguished by the impression it gives that one is close to the sought-for material, and the *Entsprechungserlebnis*, by which one is assured that the material is correct, that it has snapped into its proper place. These two experiences are relational, the materials themselves are substantive and generally palpable. Simoneit (29) set up problems in thinking and reasoning which involved the use of artificially created concepts. Before these concepts could enter into creative thought they had to be divorced from concrete representations and acquire symbolic reference. From this point on they functioned as pure *Bewusstheiten*. The author is convinced that sensory ideas play a very unimportant rôle in thought, that thinking and reasoning proceed far more generally in formulations which defy analysis into palpable components. Willwoll (45) is of the same persuasion. His Os were given pairs of words of very different meanings and were required to find superordinate concepts

applicable to both words. Their reports reveal a certain amount of sensory material, but this content rapidly gives way to symbolic ideas in which the sensory component is in no way adequate to the burden of supporting the wealth of conceptual meaning.

In Dunn's detailed study of reasoning actual legal cases on which judge and jury had exercised their acumen were used, as well as geometrical problems (8). The essential character of reasoning, on its formal side, may be regarded as the *insight* into the relation between premise and conclusion. The awareness of this relation is an immediate bit of knowledge that cannot be reduced to any category of sense experience. The psychological mode of appearance of the premises may also be described as conceptual rather than sensory and imaginal. No sense qualities, such as hard, soft, red, blue, are adequate to the knowledge contained in the relations and concepts of thought and reasoning. Imagery at times appears in reasoning, but only as an incidental experience. Clark's Os were asked (4) to solve problems without making use of any explicit form of behavior. Various experimental devices were employed to determine the rate of thinking, the kind of mental processes involved, and the influence of bodily movements and distractions. The results reveal the presence of concrete and verbal imagery during thought. This imagery is richer in rapid thought. But there are intervening periods when sensory material is entirely absent, when consciousness is imageless. The bodily concomitants of thought are slight and unimportant.

Not all of our authors reach conclusions which favor the impalpable character of thought. A few occupy, *e.g.*, an intermediate or non-committal position in that they recognize that non-sensory experience exists, but insist either that (a) it is indeterminate with respect to the real nature of thought or (b) coördinate with sensory contents or (c) dependent for its existence on marginal traces of imagery. And one or two authors deny roundly the existence of impalpable mental process. Some of the conclusions below derive from work done not directly on the act of thought but upon experiences which presumably enter into thought.

Katona (18) argues from conclusions based on psychophysical judgments to the nature of the general experience of relationship which colors so much of higher mental life. Generally the perception of a relation is immediate and unanalyzable, and to this extent is non-sensory. But under favorable circumstances the genesis of a relation may be detected before it vanishes behind the bare awareness of its

existence in subsequent experience. A relation originates in an experience of transition from one term to another. This transitional experience is grounded in an ultimate datum which has about it something very like movement. Sassenfeld's work (25) on recall of various sensory impressions revealed the possibility of analyzing the course of reproductive consciousness into three moments or levels. The first level contains revived impressions with very few, if any, modifications of their original structure. In the second level are found complicated awareness of alterations which have taken place. These awarenesses, so essential to productive thought, are, at this stage, still embodied in the sensory structures themselves. A third, and highest level, contains the complex structures of meaning, concept, and thought which are generally reported as impalpable but which, nevertheless, have a close affiliation to the ramifications of the sensory patterns of the second level. By repetition of juxtaposed arbitrary items Jacob's Os (17) were led to the formation of new concepts. These concepts seem to have their origin in unanalyzable feelings of familiarity. As imaginal factors attach themselves to the original affective elements the concepts become articulate. Further repetition reduces the ideational content to the point of disappearance. The affective and ideational contents of conceptual experience are inextricably interwoven. Flach calls attention (10) to a phenomenon the neglect of which he thinks has caused confusion in the matter of imageless thought. There can be no question that much thinking, especially the reproductive sort, proceeds in conceptual (impalpable) fashion. But there come moments in hard thinking when progress is blocked until the path is cleared by way of a symbolic schema of thought. These schematic patterns of *productive* thought are palpable, and contain within them the new data of knowledge. The reports given by the Os in Hermann-Cziner's experiment (14) reveal three different kinds of word-understanding: (a) sheer understanding, in which there is no awareness of differences, parts, or sensory elements; (b) representative understanding, which may be either palpable or impalpable; and (c) explicative understanding, which is mediated through other meanings, generally in palpable form. The development of meaning, in Wheeler's experience (42), involves three stages: (a) the original or given process; (b) a subsequent process which interprets the first; and (c) a third process which constitutes a final interpretation. In every stage kinaesthesia is the core of the phenomenon of meaning. The rôle of kinaesthesia in meaning was given special consideration in Shim-

berg's experiments (28). She discovered that kinaesthesia is a very prominent constituent in the search for meanings of words, and that meanings are very rarely present without some imagery to support them, if not kinaesthetic, then visual or auditory. Ogden, in reinterpreting some of his earlier results (23), believes that imageless thought has passed into the limbo of inert conceptions, but considers it a special merit of *Gestalttheorie* to have placed meaning in a new light. A stimulus-word, which according to the older view must be supplemented associatively in order to achieve significance, is itself the *nucleus* of the meaningful experience. Phenomenally the sensed word is already its meaning; for there are no meaningless experiences. But Weld, Wilson, and Don (6, 46) report findings of delayed and lapsed meanings. Meaning and sensory process, in other words, may vary independently. Bichowsky (1) argues that there is no evidence for a new psychic entity corresponding to a relation in the sense that there is new psychic stuff (the image, sensation, etc.) corresponding to a thing or object.

The most emphatic denial of impalpable experience comes from Wheeler whose point of view derives support from observations on a synaesthetic subject (5, 43). Meanings consistently fail to appear or develop in the absence of the synaesthetic imagery which serves as context to the given process. Reasoning, moreover, is absolutely dependent on the presence of synaesthetic imagery. No reasoning takes place in its absence.

By a novel method of recombining previously presented syllables Heinrich (13) was able to study the formation of new ideational complexes. It was discovered that these complexes, fashioned as they were out of the materials presented in the experiment, followed no principle of associative integration; that, as a matter of fact they were often constructed of items between which there were no associational bonds. The glue of integration must be sought outside the realm of associationism. Usnadze (38) set for himself the specific task of discovering the psychological processes involved in assigning names to objects in the hope of throwing light on the more general problem of the evolution of language. The Os were presented with meaningless visual forms to which they were to assign words selected from a list of unfamiliar sounds of a given dialect. At the basis of the connections thus established between the visual forms and the sounds there lies a quite definite psychological state. The forms and sounds do not come together in haphazard fashion, but follow, rather, certain uniform principles. One of these is assimilation. But this

associative factor is of minor importance and operates only in a few instances and can be demonstrated to be very generally subordinate to the *Gestaltverwandtschaftsfaktor*, the experience of consensence offered between certain sound-patterns and visual forms.

By presenting Os with problematic situations and difficult dilemmas it was possible for Martin (20) to secure descriptions of the events which forced a choice or decision. The process of choice begins with the acceptance of the *Aufgabe*, proceeds to a period of exploration in which organic and kinaesthetic contents play a large rôle, and comes to rest at the moment of acceptance of one of the presented alternatives. According to the degree of finality in this last period the decisions may be differentiated into those of preference, conflict, and indifference. A new device for investigating the acceptance of an *Aufgabe* is reported by Blumenfeld (2). The observer is left uninstructed in the face of the material presented him. This material, of whatever sort it may be, is so arranged that an observer, after a short lapse of time, will begin to suspect the operation of some carefully chosen plan for the presentation. At this point it is possible to examine the initiation of general *Aufgaben* which quickly narrow down to specific ones. Griffiths (11) finds that mental operations in affirmation are more rapid than those in negation, and singles out other differentiating characteristics which make it possible to refute the view that all negation involves affirmation, that the judging attitude is always a positive one. English (9) holds that abstraction begins either with assimilation of material to a familiar conceptual category or with analysis into components which will permit of such assimilation, continues through various stages of associative reconstructions, and in the purest form is revealed as the conscious intention to consider a given presentation in isolation from some or all of its relations. Wilcocks (44) points out that as the result of an error in procedure in Külpe's famous experiments on abstraction it was not possible for him to prove that the percentage of correct reports is higher where *Aufgabe* and report coincide than in the case where they do not; but that if the experiments are performed with this error eliminated his conclusion is true in principle.

Myers (22) believes, on the basis of studies in problem-solving, that thinking can only proceed when there are available the appropriate patterns of thought, and that even in abstraction and "imageless thought" there still remain vestiges of specific patterns. And Mather and Kline (21) maintain that in the solution of puzzles trial-and-error responses are gradually replaced by those of control and

purpose, and that the knowledge gained in the solution of one puzzle is applied to the solution of the next, provided O sees the similarity of the parts and the plan.

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SPECIAL REVIEWS

HOLLINGWORTH, H. L., *Psychology: Its Facts and Principles*. New York: D. Appleton and Company, 1928. Pp. xviii+539.

It is seldom nowadays that anyone lays claim to a *system* of psychology. This may be due to the fact that we psychologists are still dreadfully afraid of being mistaken for philosophers. It may be due to an honest belief that the *facts* of psychology are soon, by virtue of their solid factuality, to stand without speculative assistance. But whatever that case may be, there are still appearing in undiminished number works which are to be distinguished from the run of textbooks in that each offers a well-knit treatment of its author's peculiar outlook on psychology as a whole. Carr's *Psychology*, Dunlap's *Elements of Scientific Psychology*, Bentley's *The Field of Psychology*, and Kantor's *Principles of Psychology* are works of this general, systematic type. Professor Hollingworth's recent book is in our estimation a noteworthy addition to the literature on the broader, theoretic framework of psychology. We do not imply that it is *not* a textbook. We mean rather that the book is chiefly important as a contribution to serious systematization.

As one might have predicted from recent writings of Hollingworth, his central concept is that of *Redintegration*. After taking a number of preparatory steps at the logical and epistemological level, the author introduces us (Chapter IV) to the general laws of redintegration. Among these, this one leads the way:

" . . . consequents (responses) may follow fragments or partial details of their former antecedents (stimuli)."

In elaboration of this primary law there are something like thirteen others. For example:

"The completeness of a redintegrated response varies with the completeness of its stimulus."

and

"Some of the details of an antecedent context have special instigative potency."

and

"The potency of a given detail varies with a great many determinants, such as prominence, temporal position, contextual inclusion, recency, frequency, and concurrent details."

By enumerating such general laws of redintegration Hollingworth establishes practically the whole of his larger framework in a single chapter. The remainder of the book applies and reapplies these fundamental principles to the domains represented by the accepted categories of psychology.

As the author wends his way through the facts of psychology he is not entirely innocent of neglecting points at which the application of his system is ambiguous. Hollingworth is not the first to be bored, or logically embarrassed, by the sensory processes. He quickly rids himself of the usual obligations of the field by speaking of a borderline science, "the physiology of the senses," where these matters can be found. "But we do not consider that this body of knowledge has any immediate place in a survey of psychology" (p. 444). The reviewer is more astonished, however, at the scope of Hollingworth's system than at its occasional neglects. With the recent accumulation of empirical facts and techniques systematization has come upon hard problems. To force into one perspective the materials of the clinic, the objective data on learning, the statistical findings and conceptions within the field of individual differences, and the typical introspective data on the thought processes is a task that might easily tempt one to invent several non-psychological sciences. That Hollingworth has had to leave out so little is a real tribute to his system. Perhaps he would say that his results are due to the fact that he has no system, that he has simply *described* the situation as it really stands. The possibility ought to be mentioned in order that the reader may understand that this talk about Hollingworth's system is talk about that to which Hollingworth, himself, makes no explicit claim.

An enumeration of the chapter titles of the work before us would give an inadequate idea of the freshness and extent of its viewpoint. In the main these titles are conventional. Indeed we were delighted to see in such a progressive thinker so little of the fear, current among progressives of lesser metal, of Thought, Imagination, Perception, Feeling, Voluntary Action, and so on. And although Hollingworth is constantly throwing new light on old topics, there is in the main little distortion of the better established definitions of these topics. Where he feels it necessary to use old terms in not exactly the usual manner he is exceedingly careful about definition. He makes no attempt to use the notion of *consciousness as such*. But he makes it quite clear that what he means by *subjective* is the *relatively private*. The *mental* event is that of the type described by his principle of redintegration. *Ideas* are such only because of their mode of func-

tioning. Thus a word, an image, or a kinaesthetic pattern *can* be an idea if it functions symbolically. *Feelings* are all those events that are mainly identifiable with the organism itself. These notes on definitions are incomplete, yet they are typical and important instances of Hollingworth's departures from strict orthodoxy. He seldom if ever uses an old term in a completely novel way. He not infrequently adopts with fair warning what we might call a minority meaning of a term.

A work on the general theory of psychology can proceed with historical emphasis or it can free itself from history in the hope of attaining thereby greater internal consistency. Like most other American writers of the time, Hollingworth makes no effort to place in historical setting his larger viewpoint or his dealings with special topics. He plunges straightway into his principles of redintegration without showing where he got these notions or how he has modified original sources. He illustrates his principles bountifully and clearly, but it is, of course, mere expository device to act as though the principles had simply turned up in these illustrative facts. But where did they come from? In a special preface for psychologists (he has another for instructor and student) Hollingworth says briefly that the point of view is not that of "associationism," though it has superficial resemblance to that doctrine. In his system: "It is not 'mere ideas' that are connected, but primal events in nature." The reviewer feels that this disposition of the case is too easy. Granted that Hollingworth applies the dynamic notions of integration and disintegration to a realm of much wider scope than did the associationists generally, there is no escaping the fact that the main historical source of such principles lies in that selfsame doctrine of association. Since the days of associationism, biological thought has made progress and become mixed with the psychological. And the dominant trend in America has been the development of a psychological outlook which might be described as associationism, criticized and amplified from a point of view at once biological and practical. The fact of the matter is that Hollingworth falls into line with this American tradition, though we should insist that he is very near to the head-end of the procession.

In the earlier functional and dynamic psychologies of America there was a strong teleological flavor. Mental activities were thought of as being *in the interests of* better adjustment. Whereas our grandfathers were taught that habits are bad, the situation fifteen to forty years ago was quite the reverse. The psychological categories were

identified with some good they could do. Even Consciousness was given the part of a dashing hero who arrives just as Automatic Equipment falls frustrated and exhausted in his attempts to preserve us from the Novel Situation. There is none of this in Hollingworth. He soberly tells us that: "The minds of saints and sinners alike follow the redintegrative paradigm." And, better still, he introduces us to the fundamental conception of redintegration by showing how that principle operates in a case of war neurosis.

It is a notorious fact that the present-day psychologist sets up his system upon the basis of unadmitted philosophical assumptions and that his excuse for not making his assumptions clear is the lame one that it is his duty to avoid metaphysics. If all psychologists worked upon the basis of a common epistemology and logic this reticence would be unobjectionable. There would be little need for bothering about anything but the internalities of a given system and its relation to accepted fact. As it is, the avoidance of frankly philosophical discussion is an ostrich-like performance. Hollingworth is an exception in this regard. He gives us his philosophy of nature, of science, of observation, of conjecture. He does not name his philosophy; he does not even say he has one; but the reviewer would call it *positivism* because it seems to have such faith in unprejudiced description. One practice of Hollingworth is troublesome, though it is not at all unique with him. In speaking of the scope of psychology he identifies the animals of animal psychology as "that great group of visual-tactile objects" (p. 9). Such procedure of bringing the technical concepts of psychology to bear at the level of methodology or history of science is confusing unless one considers that the terms of one's science really reach out into the knowledge problem. Perhaps Hollingworth thinks so. As we have said, there is strong evidence that he has faith in description. At any rate he is hardly instrumentalist or conceptualist. ". . . temporal relations are part of the intrinsic 'stuff' of nature, not frames within which events happen, nor spectacles through which we view them" (p. 111).

All in all this book of Hollingworth's is serious business. It has little pedagogical flavor about it, but the student ready for strenuous thinking will get a great deal out of it in the way of fact and systematization. He should be warned, however, that what he finds in the book besides facts will be not *the system of psychology*, but *Professor Hollingworth's system*.

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NOTES AND NEWS

DR. GÖTZ MARTIUS, professor of philosophy at the University of Kiel, died on May 27 at the age of seventy-five years.

THE deaths are also announced of Dr. Vittorio Benussi, professor of psychology at the University of Padua on November 24, 1927, at the age of forty-nine years; Dr. Wladimir Bechterew of the University of Petrograd on December 27, 1927, at the age of seventy years; and of Antonin Prandtl on December 25, 1927, at the age of forty-seven years.

DR. ROLAND CHARLES TRAVIS has been appointed research associate in psychology, with the rank of assistant professor, in the Institute of Psychology at Yale University.

DR. LEONARD CARMICHAEL has been promoted to professor of psychology and Director of the Psychological Laboratory at Brown University.

THE Thirteenth Annual Meeting of the Optical Society of America and the simultaneous Exhibition of Optical Instruments under the joint auspices of that society and the Bureau of Standards will be held at the Bureau of Standards in Washington on November 1-3, 1928. The Bureau extends a cordial invitation for this exhibition to anyone interested. All who have instruments or other material of optical interest which they desire to enter in the exhibition are invited to communicate with Dr. I. C. Gardner, Chairman of the Exhibition Committee, Bureau of Standards.

DR. PAUL C. SQUIRES of the University of Vermont has been appointed assistant professor in psychology at the University of Kansas.

A CORRECTION

In Dr. Bingham's introduction to *The Effects of Music*, edited by me, it is erroneously stated that the Edison Prize was awarded to the study by M. F. Washburn, M. S. Child and T. M. Abel. The prize was given to the paper by M. F. Washburn and G. S. Dickinson.

(Signed) MAX SCHOEN

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